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THE "DREADNOUGHT."

An interesting trial was lately had at Portsmouth, Eng., of the new British double-turreted war steamer, Dreadnought. This vessel represents the latest advances in marine construction for war purposes. Her load displacement is 10,950 tons; length, 320 feet; beam, 63 ft. 10 in.; depth of hold, 19 ft. 2 in.; thickness of side armor, 8 to 14 inches; external diameter of turrets, 32 ft. 3 in.; armor, 14 in.; armament, four 38 ton guns. [For account of the remarkable power of these guns, see SUPPLEMENT, No. 59.]

The Dreadnought is engined by Messrs. Humphrys & Tennant, of Deptford, who have supplied the machinery to the Thunderer, Alexandra, Téméraire, and other large men-of-war. Each propeller, which has a diameter of 20 ft., and a mean pitch of 23 ft. 6 in., is driven by an independent set of vertical compound inverted engines of the collective indicated power of 8,000 horses. Each set consists of three cylinders, the high-pressure, which is 66 in. in diameter, exhausting into two low-pressure cylinders, each having a diameter of 90 in., and a stroke of 4 ft. 6 in. They are all steam jacketed, the high-pressures adjusted to 60 lb., the working pressure of the boilers, and the low pressures to 30 lb. The diameters of the piston and connecting rods are 9 in., 6½ in., and 7 in. The air pumps are worked off the low-pressure pistons, and are formed entirely of gun-metal. Placed fore and aft, immediately under the low-pressure cylinders, they allow of a very compact and accessible arrangement of engine, the condensers forming the midship framing, while the wing framing consists of two wrought iron columns to each cylinder. The surface condensers contain over 16,500 ft. of cooling surface, and are fitted to work as common condensers. The condensing water is supplied by two powerful centrifugal pumps, which are also designed to draw directly from the bilge. An extra bilge suction is provided, so that the air pumps can pump directly from the bilge in case of an accident. The engine shafting is composed of three pieces, each piece having a length of 10 ft. 7½ in., and a diameter of 17¾ in. The diameter of the propelling shaft is 16 in., and of the iron shaft in the stern tubes, 18 in. The main engines are started and reversed by an auxiliary engine having cylinders of 6 in. in diameter, and a stroke of 8 in. The ship is also provided with six ventilating engines, turret-turning engines, two auxiliary fire-engines, and four main fire-engines, ash-hoist engine, etc.

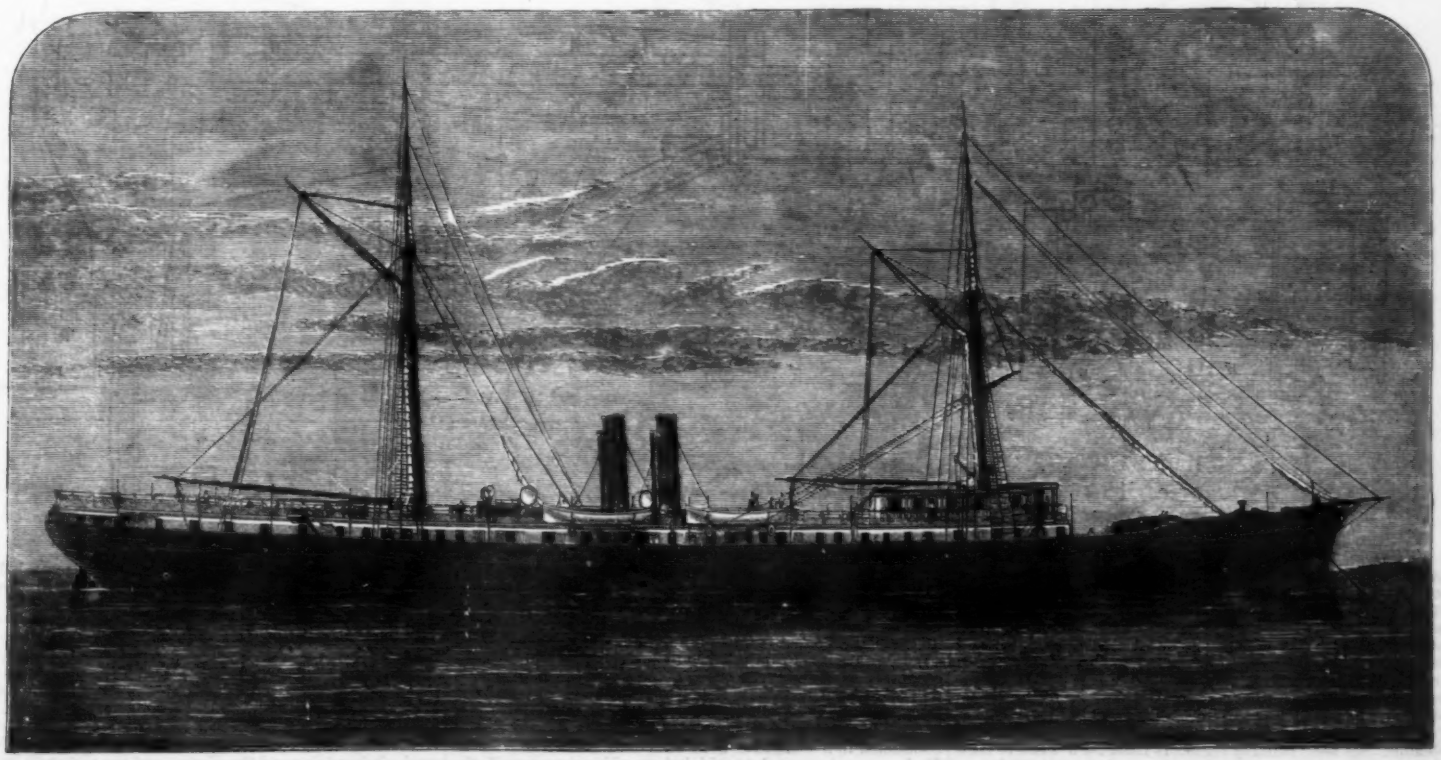
The steam for the main and other engines is supplied by 12 boilers and an auxiliary boiler, all of great solidity of workmanship. They are cylindrical in shape, though the section is scarcely a circle, having diameters of 11 ft. 10 in. and 12 ft. 2 in. respectively, the length being 14 ft. The shell plates of the main boilers are ¾ in. in thickness, the tube plates ⅞ in., and the back ¾ in. The tubes are 3 in. in diameter. Each of the main boilers has three furnaces, of which the inside ends are connected to a single combustion chamber, while on the outside they are fixed to the front of the boilers. The firegrates are 6 ft. 10 in. long, and are fitted with wrought iron firebars, 3½ in. deep, 1¼ in. broad, and 2 ft. 3 in. in length. There are 66 in each furnace. In order to show the enormous capacity of the mechanism for generating steam, and at the same time to illustrate the complicated character of what may be looked upon as the unseen portions of a modern man-of-war, it may be mentioned that the main boilers of the Dreadnought contain each 234 brass tubes and 64 iron stay tubes; while the auxiliary boiler contains 84 of the former and 12 of the latter. The heating surface of the tubes in each of the main boilers is 1598.472 square feet; of the furnaces, 74.589 square feet; and of the combustion chamber, 152.090 square feet. The total heating surface of the main boilers is thus 21,901.812 square feet, the heating surface of the auxiliary boiler being 123.69 square feet. Each of the main boilers, again, contains 169 tons of water, and affords ample steam space. In addition to the ordinary safety-valve box, containing a couple of spring safety-valves, each boiler is fitted with a supplementary test valve, loaded with a lever and weight, and placed on the front of the boiler. The stop-valves and safety-valves can be worked from the stockhole floor. The boilers are also provided with two pressure gauges each, one of which is graduated to 80 lb., and the other to 120 lb., the intention being that one shall act as a check upon the other. The whole of the boiler mountings are of gun-metal. The contents of the coal bunkers, in which the fuel for this costly apparatus is stored, is 6192.2 cubic feet.

The mean power developed by the engines during the six hours was 8216.28, or 216.28 horses beyond the contract. More could have been readily obtained had the economic purposes of the trial not intervened. The blasts were not used from first to last. Indeed, the difficulty was to regulate the amount of steam generated, so as to maintain a steady and uniform power without its blowing off to waste. The total means of the twelve half-hours were: Pressure of steam in boilers, 60.32 lb., and in engine-room, 57.32 lb.; vacuum in condensers—starboard, 27.04 lb., port, 27.33 lb.; revolutions—starboard, 67, port, 67.18; mean pressure of steam on pistons, high 31,603 lb., low 9.137 lb. One of the most noticeable circumstances connected with the observations was the almost uniform vacuum that was obtained. The vacuum in the starboard condenser only varied once from 27 in. during the whole time the ship was under way, while that in the port condenser never varied more than half an inch, and that only twice. The coal burnt on the trial amounted to 50 tons 1 cwt. 10 lb., which is equal to 2.27 lb. per indicated horse power. The engines were stopped from full speed in 18 seconds, and started astern in 8 seconds; and from going astern were started full speed ahead in 15 seconds. The trial passed off without a hitch of any sort, and Mr. Humphrys was warmly congratulated by the officials on board on the results. The Dreadnought, in addition to her main engines, is provided with starting engines, capstan engines, steam-steering engines, six ventilating engines, two auxiliary and four main fire-engines, and engines for moving turrets, hoisting ashes, etc.

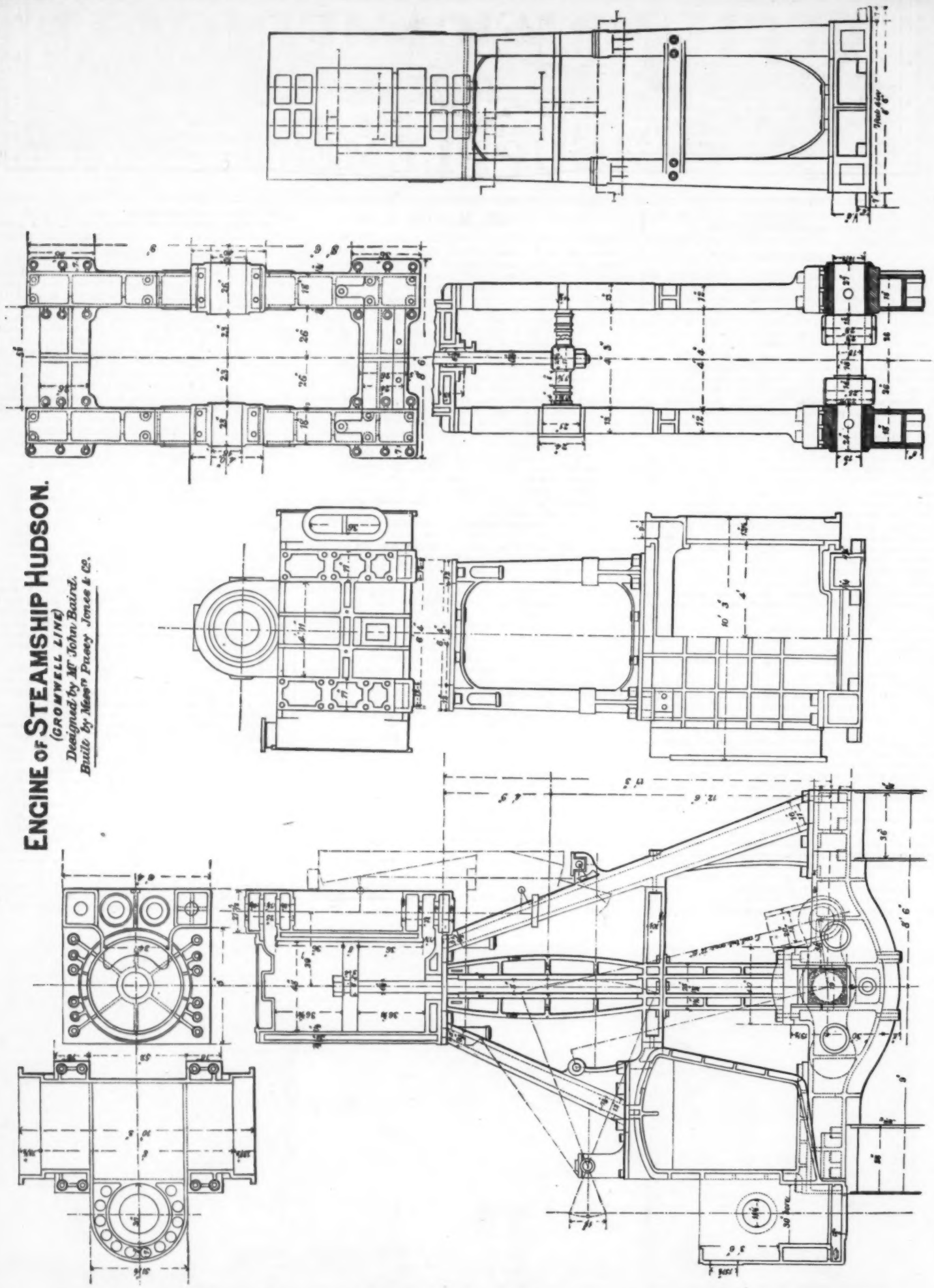
THE target for the 80-ton gun consists of four 8-inch rolled armor-plates, with three 5-inch intervals of teak, making thus 32 inches of iron and 15 inches of backing. The plates are by Sir J. Brown & Co., of Sheffield. Each plate weighs about 22 tons.

ENGINES OF STEAMER HUDSON.

"THE relative merits of simple and compound engines may," says the London *Engineer*, "be regarded as a threadbare subject of discussion; but we venture to think that it has not yet lost its interest for our readers, and we have some pleasure, therefore, in placing before them certain facts which, while bearing on the questions involved, possess at least the charm of novelty at this side of the Atlantic. The events of the last twenty years have dissipated many prejudices, and placed the entire theory of the steam engine on a sounder basis than it ever possessed before. No one now regards Marriott's law as applicable to the practical expansion of steam in a metallic cylinder; and it is well understood that the similarity which occasionally exists between an indicator diagram curve and a hyperbola is nothing more than a chance coincidence. It exhaustive experiments can be regarded as possessing any value, then it may be taken as proved that in practice a simple engine will use steam as economically as a compound engine. The heat trap theory, like many other antiquated notions on mechanical subjects, is no longer regarded as of the smallest applicability to the steam engine, save by a few individuals who prefer abstract notions to the logic of facts. It is, at last, generally understood that the economy of the compound engine is due not to compounding but to the use of large measures of expansion, economical boilers, excellent vacuums, and the use of fresh water—by which alone about 15 per cent. is saved in fuel by the suppression of the loss due to blowing off necessary when sea water is used as feed. The compound engine enjoys favor for reasons which really have nothing to do with economy of fuel. Compounding gives more equal "turning," for one thing; and while sliding valves worked by eccentrics are employed to regulate the admission and emission of steam to and from a cylinder, it is very difficult to carry out expansion neatly save in compound cylinders. One great argument in favor of the compound system deserves a moment's notice. It is that it would be unsafe, or even impossible, to admit high-pressure steam at once on a large piston. Now, it is a matter of fact that in many marine engines the reduction in pressure due to the use of the small cylinder does not amount to much more than 10 lb. or so; that is to say, while 60 lb. steam is admitted to the small, 50 lb. steam is admitted to the large cylinder. But, waiving this point, we have the fact remaining that holders of the opinions we have just named are guilty of a strange inconsistency. They will build two compound engines, the one with cylinders respectively 20 in. and 40 in. in diameter, and the other with cylinders 40 in. and 80 in. in diameter. They fear to admit 60 lb. steam in the first case to a 40 in. cylinder, but they have no hesitation in doing this with the second engine. In a word, no one has attempted to draw a line and say, 'If you make a piston larger than this, you must use low-pressure steam.' The whole thing turns on the strength of parts. If the cylinders, pistons, connecting rods, etc., are properly designed, there is no risk whatever in using steam of any pressure we please. An ounce of fact is, however, worth a bushel of theory; and we are about to place facts before our readers which prove conclusively—first, that single cylinder engines can be used



AMERICAN SINGLE-ENGINE STEAMSHIP HUDSON.



ENGINE OF STEAMSHIP HUDSON.
(GROMWELL LINE)
Designed by Mr John Baird.
Built by Messrs Pusey Jones & Co.

at sea with the most complete success; secondly, that long strokes can be employed with success at sea; thirdly, that single cylinder marine engines may be worked without fly-wheels; fourthly, that high pressures can be employed without the smallest risk in single cylinder marine engines; and fifthly, that expansion can be effected to absolute perfection in single cylinder marine engines. All this is proved by the experience had with the engines of three large American steamers, to which we shall now refer more particularly.

"For some years a line—known as the Cromwell line—of steamers has been running regularly from New York to New Orleans, a distance, in round numbers, of about 1,800 knots. The engines of these steamers have, therefore, to work day and night for considerable periods. Three of the vessels are known as the New Orleans, Knickerbocker, and Hudson. Their principal dimensions are given in the table at the end of this article. We shall confine our attention to the most recently built of the three, viz., the Hudson. A view of this vessel, prepared from a photograph, will be found on an adjoining page. From this it will be seen that she is an exceedingly handsome type of sea-going screw steamers, and it will be granted, we think, that if machinery of a given kind is successfully used to propel her, it may be used with equal success in the case of other ships. In a word, an experiment conducted to a successful issue on board such a ship as the Hudson, carries a weight which it would not possess if the ship and her engine were smaller or made shorter voyages in less tempestuous seas.

"Now the Hudson is propelled by a very remarkable engine, one quite unlike any met with in English practice. Mr. Baird, an American engineer of eminence, by whom both the engine and ship were designed, has, with a courtesy deserving all praise, placed at our disposal a complete set of tracings, showing the smallest details of the Hudson's machinery, and copied from the actual drawings from which that machinery was built. We give an elevation and sections of the cylinder, valve seats, and framing of the engine.

"The Hudson is propelled by one single cylinder surface condensing engine, with an overhead inverted cylinder, the stroke being 6 ft., and the diameter of the piston 48 in. The working pressure is 90 lb. absolute, or 75 lb. safety valve load. There is no fly-wheel, but the weight of the crank,

etc., is counterbalanced by a back crank, as shown in the drawings. The valve gear is very peculiar. It will suffice to say that steam is admitted to and exhausted from the cylinder by four independent double-beat poppet valves worked by wipers on rocking shafts, and cams on the crank shaft. It was deemed expedient to get the sharpest possible admission and cut-off, and 90 lb. steam is thrown on this 48 in. piston at each stroke in a fraction of a second of time, while the cut-off is literally as quick as lightning, and quite different in this respect from anything that can be had with slide valves. The valves are of great size, as will be seen from the drawings, and their lift is very small. As they are accurately in equilibrio, and provided with dash pots, the valve gear, complex as it appears, works in silence and without jar or vibration. In going into or out of port full steam is carried almost throughout the entire stroke, the throttle valve being almost closed. The engine never sticks on the center, and is handled with the utmost ease by a couple of men, notwithstanding its great size. Steam is in regular work cut off at from one twelfth to one fifteenth of the stroke. The area of a 48 in. cylinder is 1,810 square inches, and the strain brought to bear at the beginning of each stroke on the piston rod of the Hudson is not less than $1810 \times 90 = 162{,}900$ lb., or over 72 tons. What do English advocates of the compound system think of this? It is difficult to realize the fact that an engine like that of the Hudson can work, silently, at 60 revolutions per minute, or 720 ft. of piston speed. On this point we cannot do better than quote the following passage from a letter concerning this ship, which we have received from Mr. Buchanan Henry:

"'Theoretically, most engineers would look for great vibration and unequal motion in an engine suddenly admitting steam of 90 lb. pressure upon the piston, then cutting off abruptly after the piston had only traversed five or six inches in six feet of stroke, and then diminishing the pressure progressively by expansion until at the end of the stroke the terminal per square inch should not exceed five or six pounds absolute. Many would naturally expect that the hammer-like blow of such high steam upon the piston at the beginning, dying out to nothing at the end of the stroke, would rapidly tend to shake the engine itself to pieces, and strain the ship's hull. The answer is that, in the history of mechanical contrivances, it is often found that theory and practice are not on the most friendly terms. It is notably so in this instance. There is, in fact, less vibration or shake, I can safely say, in the Hudson's engine room than in that of any short stroke or compound steamship I have visited, and I have examined a number. Although you may be standing close to the ponderous 12 ft. connecting rod, making nearly 120 strokes per minute, you would hardly think the engine in motion but for seeing the long sweeping stroke, and hearing the clear sharp click of the expansion gear, as there is no sensible shock, jar, or tremor. This may be partly due to good workmanship, but not wholly, as no excellence in this respect would counteract any serious defect in design.'

"But evidence of the durability and efficiency of the engines of the Hudson, quite independent of personal testimony of any kind, is supplied by the fact that she performs her trips regularly and punctually, that she keeps good time in all weathers, and that the consumption of fuel is smaller than it would be with a compound engine of twice the weight, amounting as it does to only 1·36 lb. of anthracite coal per horse per hour when the engine is indicating 1300-horse power.

"We stated not long since that noteworthy examples of American engineering must be sought elsewhere than in the Philadelphia Exhibition, and the machinery of the Hudson supplies the third proof of this fact which we have laid before our readers. The colossal pumping engine at the Friedensville Zinc Mines was the first. A huge stern wheel tugboat on the Ohio was the second. Is it not about time that Englishmen should fully recognize the wonderful power of adapting means to an end possessed by American engineers? With the example set by Mr. Baird before them, our countrymen can scarcely fail to perceive that we have yet something to learn, and that there are possibilities in marine engineering hitherto undreamt of on this side of the Atlantic."

Iron Vessels.	New Orleans.	Knickerbocker.	Hudson.
Indicated horse-power developed	—	780 to 860 H. P.	1,150 to 1,450 H. P.
Registered tonnage	1,440 tons	1,642 tons	1783
Length, breadth, depth	253×33×24	260×33½×22	294×34×23
Bulwarks, height	3 ft. 9 in.	3 ft. 9 in.	3 ft. 3 in.
When built and put on route	1872	1873	1874
Displacement with ordinary load	2,244 gross tons	2,519 gross tons	2,950 gross tons
Mean draught, loaded ordinary freight	18 ft.	17 ft.	17 ft.
Engine, Baird's single cylinder, poppet valve, long stroke expansive	48 diam., 5 ft. stroke	44 diam., 6 ft. stroke	48 diam., 6 ft. stroke
Propeller, true screw	14 ft. diam., 20 P.	14½ ft. diam., 21 P.	15 ft. diam., 22 P.
Boilers, return tubular	Two boilers.	Four boilers.	Four boilers.
Number of furnaces and length	Ten; 6 ft.	Twelve; 5½ ft.	Twelve; 6 ft.
Width, length and height	14 ft. 10 in.×12×14	9×12×12·4	9·6×13·8×12·6
Tubes, diameter and length	536; 3 in.×9 ft.	532; 3½ in.×10 ft.	560; 3½ in.×11·8
Steam chimneys	14 ft. high, 6·6 diameter	—	—
Drums, two; one for two boilers	—	12 ft. high, 5·6 diameter	13½; 5·10 diameter
Pres. of steam above atmosp. and absolute	50 lb.; 65 absolute	66 lb.; 71 absolute	75 lb.; 90 absolute
Point of cutting off	¼ to ½	¼ to 1/11	1/8 to 1/5
Vacuum	25 in.	26 in.	26 in.
Temperature of steam	327 deg.	340 deg.	370 deg.
Revolutions per minute, ordinary work	57 to 60	57 to 60	56 to 59
Revolutions, highest No. for one watch	70	70	69
Distance from New York to New Orleans, wharf to wharf	1,800 sea knots.	—	—
Average trip out, against current	6 days 10 hours	6 days 7 hours	6 days 7 hours
Average trip back, with current	5 days 17 hours	5 days 14 hours	5 days 14 hours
Shortest trip out	6 days 8 hours	5 days 20 hours	5 days 21 hours
Shortest trip back	5 days 12 hours	5 days 6 hours	5 days 10 hours
Greatest run in 1 day; no wind or current	310 knots	330 knots	335 knots
Coal in twenty-four hours (anthracite)	16 tons	17 tons	19 tons

A NEW STEAMSHIP DEPOT.

THE new depot which the General Transatlantic Company has been constructing at New York on the North River, at pier No. 42, is nearly finished. It covers a space of 541 feet in length by 75 feet in width, and is built in the shape of a tunnel. The vertical height at the center is 40 feet. The storage room is 32,480 square feet, and the capacity for freight is 18,270 tons, being 75 pounds to the square foot. The building is supposed to be entirely fireproof, galvanized iron being used for the most part. A water conduit four inches in diameter runs its entire length from the quay to the western extremity, to which hose can be fixed. On the east side, fronting on West Street, stands a smaller structure, forty-five feet in depth, in which are situated the offices, including a telegraph station. The exterior of this building is entirely covered with galvanized iron plating. A steam machine of seventy horse power is used to load and discharge the steamers. The building is entirely lit by gas, and the light is equally distributed through all its length by means of powerful reflectors suspended at a height of thirty feet. All the arrangements are well fitted for shipping purposes.

DETAILS OF THE ASHTABULA BRIDGE.

By EDW. S. PHILBRICK, C.E.

FEELING the incompleteness of the information given upon this subject in the public prints, and being unable to devote the time myself which a personal inspection would require, I sent my assistant, Mr. Albert H. Howland, who has had experience in designing a variety of bridge work, and whom I know to be a thorough and reliable man, to inspect the wreck in detail. From his notes made during over two weeks while the wreck was being removed, and from statements of Mr. Charles Macdonald, C.E., who had visited the wreck, I have the following facts, many of which will perhaps be new to your readers, and from which every one can make his own deductions:

THE STRUCTURE.

This was a *deck* bridge, with two iron Howe trusses, each having fourteen panels of eleven feet length. The height of truss was 19 ft. 9 in. from center to center of chords; width between centers of trusses, 17 ft. 2 in.; width of deck, 25½ ft.; length between back walls, 158 ft. The bottom chords consisted each of five lines of bars, each 5 in. x 1⅝ in., flat side up and side by side, each line consisting of two bars, one over the other, except that the third line drops the bottom bar in 2½ panels at ends of trusses, and the second and fourth lines drop the bottom bar in 3½ panels at ends. Rectangular lugs were welded to top bars at panel points to fit into transverse grooves of the cast angle blocks. These bars are in lengths of three or four panels. Splices were made by hooks fitted to square lugs on ends of bars and clamped by ferules driven or shrunk on. These ferules clasp the hook, the spliced bar and the continuous bar all at once. The angle blocks at panel points were all cast iron; bearing faces nearly plane but not planed. L-shaped lugs were originally cast on these faces 1½ in. long and ½ in. projection, to hold the braces in place, as these were originally put in, viz., with the top and bottom flanges of the I beams of which all the braces were composed, being parallel with the plane of the truss. We are told by men who were employed in its erection that when first put together some wedges were drawn on the false works, the braces being in the position above described, that the braces had been clamped at their intersections and these clamps parted, allowing the braces to buckle and the truss to sag. A few more wedges were drawn and it settled more, the braces getting some inches out of line. Mr. Stone was sent for and had it jacked up and the rods screwed up. The nuts could not be turned much. It was let down again on the false works and the braces turned 90° on their own axes. Additional ones were put in at the end panels, making six instead of four, and the bridge then stood. The little L-shaped lugs on the angle blocks were mostly chipped off to allow the braces to be turned, also some corners of braces, leaving them with nothing but friction to hold them in place; for what little was left of the lugs did not fit the new position of the braces. Paint marks now show them to have moved some inches out of place when last painted. The braces were all 6 in. I beams, rolled iron, with a section of 6 to 9 square inches, the heavy ones being supposed to be at the ends of trusses. Beginning at each abutment each panel had the following number of braces leaning forward toward the other abutment, viz.: 3, 6 ?, 4, 4, 3, 3, 3, 3, 2, 2, 2, 1, 1, 1, 0. The end panel having no counterbrace, its main braces were stayed at half length by a bolt and gas pipe strut passing to the first bottom angle block. There was no vertical end post at the abutments. The top chords had each two of their members extending over to the back wall, where they bore on rollers at one end, making a beam 12⅞ ft. span, composed of two 6 inch I beams directly under one rail of the track and carrying about 86 per cent. of the loads passing over this track, for the other beam was 17 ft. 2 in. distant. *The several braces of each set were connected only by a yoke of two rods of ⅞ in. diameter at their intersections at the center of their length, with cast packing pieces between them!* The vertical ties were 8 in number at each angle block, 2½ in. diameter at ends, and varying to 1½ in. at middle of truss. They had forged heads at top, and were upset at bottom, where nuts were applied. Their ends bore against iron washer straps, which extended across full width of chords and on the bottom chord somewhat more at the inner end for connection of the lateral brace struts. These struts were railroad bars, confined by a stirrup passing over top of rail and down through holes in bottom flange to bolt to the strap described above. They were applied at alternate panel points 22 ft. apart. The bottom lateral bracing was in panels of 22 feet, composed of flat bars, 2½ in. x ⅞ in. Their ends were hooked into recesses formed for the purpose in the cast iron angle blocks, but they had no adjustment for length. A most unique feature in this bottom horizontal system was this, that the tie braces met at the chords at points *intermediate* between those where the struts were applied and 11 feet distant, so that if they had ever been screwed up the chords would have been pulled into a zigzag or serpentine line, while in their actual condition all the lateral forces arising from the wind or from the passage of trains over the bridge, instead of being counteracted or controlled, must have been *assisted* by this arrangement to break up the alignment. The top chords were formed of five lines of 6 in. I beams, side by side, two panels long and breaking joints. Their ends abutted against cast iron lugs on the angle blocks, 6 in. high, 5 wide and 1¼ in. thick, these lugs being omitted where the bar was continuous, three at one point, and two at the next. *These I beams were connected to each other only by ⅞ in. bolts and cast spools, two in a panel!* Instead of closely fitted end bearings they were *shimmed* at the ends against the lugs of the angle blocks. It is said this was done to give the desired camber, the top chord being cut a little short for that purpose. These shims were held in place only by friction. The weight of these 6 in. I beams varied, their webs being from ½ in. to 1 in. in thickness. The heavy ones were supposed to have been in the central part of the length; but, as in the case of the braces, they were so scattered and mixed by the clearing of the ground immediately after the disaster, in erecting trestles for the tracks, that little clue was left to their original position.

No broken ones were found, but they were bent and twisted in all sorts of shapes, as were also the floor beams, and all were generally completely separated by the fall. The floor beams were also 6 in. I beams, spaced three to a panel and about 25½ ft. long. They rested directly on the top chords, which were thereby subjected to transverse strains, by the passage of every wheel on the tracks. At alternate panel points there was a lug riveted to the bottom of a floor beam, fitting against the inner edge of the top chord, thus acting as a strut for the lateral bracing. The latter was in panels of 22 feet, composed of 1¼ in. round iron, flattened at ends and formed with a hook fitting a recess in the angle block, and held down by the weight of the top chord bars. There was no adjustment of length. A stirrup passed over the floor beam acting as strut, and confined it to chord. There was originally only one track on the bridge, but of late years two had been used, spaced 7.20 ft. apart in clear, so the outer rails came almost exactly over the center of the trusses. Under these rails were two pieces of longitudinal timber, each 7 in. x 12 in., and under the inside rails three pieces of same size. Another stringer lay outside, at each edge of floor. Don't know about any in middle, between tracks. The ties covered the whole width of 25½ feet, spaced one inch apart and made of oak, 3 in. x 5 in. Besides guard timbers on edges of floor, there were guard rails inside the tracks, converging to center of track near end of bridge. This floor was better than the average of bridge floors, and if the ties were sound, as we have every reason to suppose them to have been, they would have sustained a derailed car and perhaps an engine, at least anywhere but in the middle of the width of the bridge. There was a pair of transverse vertical braces every 22 feet, made of 1¼ in. round iron, adjusted by turnbuckles. They were flattened at ends with a hook fitting a recess in the angle blocks, but were *held in place only by a top bolt of ⅞ in. diameter screwed into the castings!*

POSITION OF THE WRECKED TRAIN.

The train was moving westward on the left or southern track, speed stated at 12 or 15 miles an hour, during a heavy snowstorm, and was composed of two engines and eleven cars. The leading engine crossed in safety. The draw-bar connecting it with the second engine was broken by a transverse strain, as if it had been bent down over the edge of the abutment on the fall of the second engine into the chasm. This engine was found bottom up on top of the express car, and within a few feet of the west abutment, on the south side of the bridge. The rest of the train was heaped up between this and the east abutment, all on the south side of the bridge except the rear car, which was thrown by some oscillatory movement quite across the road bed and over the north side of the abutment. A careful inspection of the wheels removed from the river shows a few broken, others cracked. They generally show marks of intense heat from the burning wreck, but give no indications whether sound or unsound before the fall. The cracked and broken ones are but few considering the fall, some 70 feet. No evidence could be found of wheels having been derailed. Some 30 to 40 ties were found unburned, but these showed no wheel marks. Both of the enginemen deny any derailment.

POSITION OF THE WRECK OF THE BRIDGE.

The top chords and floor beams and braces were scattered by being hauled out of the way at once after the wreck, before any inspection of their exact position. The bottom chords hung together and lay in the water, nearly under where they had been in the bridge, but had moved about eight feet north and eight feet easterly, so the south chord lay near the center line of the bridge, and the other parallel on the north side. Both were curled up about a panel length against the east abutment. This indicates pretty clearly that the fall began toward the west end, the whole thing hinging for an instant on the easterly end, and thus drawing the chords eastward as they fell.

The first set of braces in the south truss at the west end had their top ends *under the north bottom chord*, and were nearly straight except where bent by the chord falling on them. This indicates that the south truss fell quite over to the north at this end before the north chord fell. The first set of vertical rods in the south truss had spread out their top ends like a fan against the west abutment. Their top angle block was jammed down to the bottom chord. The second set of rods of south truss was bent over to the south, the top angle block quite down to bottom chord. The third set of rods bent over to the north, with the top angle block nearly down. Other sets following bent north with angle block *at top* till near east end, where they again bent south. In the north truss all the rods were bent over to the north.

The indications all tend to show that the failure began near the west end of the south truss, either by the displacement or buckling of the main braces or top chord about two panels from the west end. This part of the floor sank, tipping the train to the south, while the reaction sent all that part of the bridge northward except at the second panel from the west end where the failure seems to have begun, and was therefore not influenced by the lateral reaction of the train. The top angle blocks could not have slid down on the eight rods which passed through them after the latter had changed their position, so that the braces must have ceased to support these blocks during the first instants of the fall. Considering the incoherent nature of the truss, and the frail attachments of its various parts, there seems to be sufficient elements of instability to account for the disaster without supposing any derailment.—*Railroad Gazette.*

THE ILLINOIS AND ST. LOUIS BRIDGE.

THIS beautiful work of engineering skill spans the mighty Mississippi River directly opposite to the City of St. Louis. Three long graceful arches suffice to clear the stream, which at that point is confined to a narrow channel between Bloody Island and the Missouri shore. In boldness of design, and grace and beauty of form, this bridge stands unrivaled; and it records the most brilliant engineering triumph of the age. Its construction involved the overcoming of difficulties hitherto deemed insuperable, and the solution of problems in hydraulic engineering long supposed to be impossible.

The bridge is remarkable for three things: 1. The length of its spans. 2. The depth and strength of its foundations. 3. The form and material of the arches.

1. The clear span of each of the side arches is 497 feet, while that of the center span is 515 feet. These are by far the longest arches ever built. The center span is fully *two hundred feet greater than that of any other arch ever constructed.* The longest arch in Europe is Sternberg's iron-ribbed arch over the Rhine at Coblentz, which has spans of 308 feet. The St. Louis bridge most resembles that of Coblentz, though it differs from it in several very material particulars.

2. All the foundations of the bridge stand upon solid rock. In their construction, the genius and daring of the Chief Engineer were most prominently displayed. The channel piers and the abutment on the Illinois shore were actually built and *sunk* to their resting-places through (in two cases) more than *one hundred feet of water, sand and gravel.* The method employed was, in many of its features, entirely new, and in nearly all important respects the work was on a scale far surpassing all previous similar experience.

The base of the east pier is 82 feet long by 60 feet wide, and it is 300 feet to the top of the cornice from the bed-rock.

The base of the eastern abutment contains 5,000 square feet, and its height is 196 feet 9 inches. It contains 22,453 cubic yards of masonry, and its weight, with one half the span it supports, is about 46,500 tons.

The whole amount of masonry in the abutments and piers is about 84,000 cubic yards. All the piers are faced with Eastern granite.

3. The arches, which carry the entire weight of the superstructure and all the loads passing over it, consist of eight *steel tubes* in each span.

Two tubes, placed one above the other, with triangular bracing between them, form a single "ribbed arch." The four ribs are securely bolted to the piers by long steel or iron bolts, and lateral stability is secured by diagonal bracing and a wind-truss between the roadways. The tubes are 18 inches in diameter, and are composed of straight segments, each about 13 feet long. Each segment of the tube is made of six bars of steel, each about 9 inches wide and 2 inches thick, so curved as to form a tube, inclosed in a steel envelope made of a single steel plate, strongly riveted. In the whole bridge there are 6,216 of these staves, each containing about 1⅛ cubic feet of cast steel. About 2,200 tons of steel and 3,400 tons of iron are used in the whole bridge.

Every piece of iron and steel used was carefully tested, as to strength and soundness, in a testing machine.

The strength of the arches is such that there is no possibility of their being taxed too severely. Were both railroad tracks filled with locomotives, and the upper roadway, which is 54 feet wide, covered with men as closely as they could stand, the strain upon the steel tubes would be only one-sixth of their ultimate strength.

The first stroke of work on the bridge was done in August, 1867; the first stone was laid in February, 1868. The east pier was sunk in four months.

The contract of making and erecting the superstructure was taken by the Keystone Bridge Company, of Pittsburgh. Great difficulty was experienced in obtaining steel and iron of the required strength, but, in spite of every failure of contractors and unforeseen difficulties, every part of the plan was faithfully executed. In giving preeminent place to James B. Eads, the Chief Engineer, we must not fail to mention the eminent services of Col. Henry Flad and Mr. Charles Pfeiffer, his assistants.

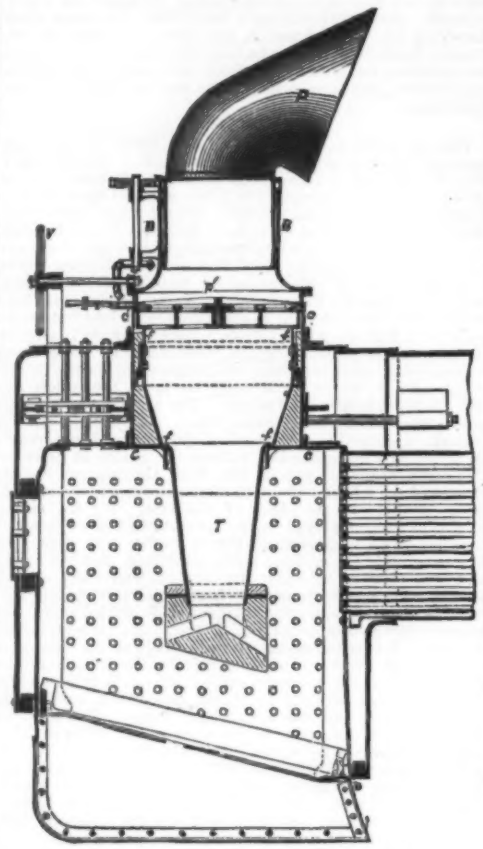
The bridge was publicly opened on July 4, 1874. The cost of the bridge, including a large amount of interest and commission accounts, is not far from $10,000,000.—*Practical Photographer.*

METROPOLITAN UNDERGROUND RAILWAY, LONDON.

THE Metropolitan Railway (about nine miles of the London underground line, forming one half of the circle which the Metropolitan District Railway nearly completes) during the year 1876 carried 52,586,395 passengers, which is 8¼ per cent. more than in 1875. This traffic is equivalent to carrying 72,036 passengers both ways daily, or 3,001 per hour, or 50 per minute for every hour of the twenty-four. The road is closed for four hours during the night, we believe, so that the actual average numbers for the time worked are 3,600 per hour and 60 per minute. The receipts from this traffic were $2,315,522 gold, or at the rate of 4.4 cents per passenger. Dividends amounting to 4½ per cent. were paid from the net earnings of the year. The total net profits of the line for the last half-year were $751,764; the expenses having been 38½ per cent. of the receipts, making the average expense per passenger carried only 1.7 cents.

SMOKE PREVENTER FOR LOCOMOTIVES.

WE illustrate in the accompanying engraving a very curious arrangement for consuming smoke in locomotives, used with great success on the Constantinople and Adrianople section of the railways of European Turkey. The device has been patented by Herr V. Reimberr, locomotive superintendent of the line; it will be seen at a glance that a wind cowl directs a strong current, when the engine is running, on the fire. The apparatus is characterized by the two following features: Natural injection, the progressive motion of the locomotive occasioning a certain quantity of hot air to spread evenly over the fire. Introduction of an iron plate cylinder between the crown of the fire-box and the outer shell of the boiler, which relieves the crown-plate of about one-third of the pressure which it generally bears. The manner in which the smoke-consumer, constructed according to those principles, may be applied to a new as well as to already existing locomotives, will be easily understood from the adjoined drawings and the following description: *c c* is the iron plate cylinder which unites the fire-box crown with the boiler-shell, and relieves the former of a part of the pressure; this cylinder is open at top and bottom; *f f*, cast iron cylindro-conical tube placed inside of cylinder *c c*; the empty space round these two is to be filled with fireclay to prevent the cooling of cylinder *c c*; T, conical cast iron tube resting with its upper flange on the lower bearing of tube *f f*; an air distributor, made of fireclay, is fixed to lower end of the conical tube T; R is a register valve for regulating the admission of cold air; B, cast-iron mantle; P, bell-mouthed air catcher, which can be turned and fixed in all positions by a gearing of tooth-wheels and bevel-wheels worked by the small hand-wheel V. The self-progressive motion of the locomotive forces the air into the air-catcher P, whose mouth must always be turned in the direction of the motion of the engine. The air, heated by its contact with the cylindro-conical tube *f f* and the cone T, escapes through the channels in the fireclay air-distributor being evenly dispersed over the surface of the burning fuel,



SMOKE PREVENTER FOR LOCOMOTIVES.

and at a sufficiently elevated temperature to produce a complete combustion.

The apparatus has been fixed to a six-wheeled all coupled goods engine, weighing 36 tons. The wheels are all between the fire-box and the smoke-box. The fuel used is Cardiff and Newcastle coal mixed, and the consumption on passenger trains equalled 11 to 12 kilos. per millimetre. The apparatus has been at work since May, and saves a large proportion of fuel, besides completely preventing smoke. Between Constantinople and Adrianople the country rises twice, necessitating inclines of 1 in 60; ordinary locomotives, therefore, have to work hard, and the increased draft used to fill the smoke-box with unburned particles of coal. Since the application of Herr Reimherr's apparatus the smoke-box remains almost empty, and all the coal formerly carried into it unburned is saved. The trains do not go faster than about 18 miles an hour; it is, therefore, supposed that the apparatus with express engines would act much more vigorously.—*The Engineer.*

THE RAILWAYS OF THE WORLD.

THE title of this article deserves a word of explanation. The subject denoted by it is enormous. How is it possible to say anything concerning it which is worth saying within the limits at our disposal? We venture to hope that before we have done we shall be able to justify our selection. At the end of the year 1873, the Honorable Mr. Gillies, Australian Commissioner of Railways, informed Mr. T. Higinbotham, M.I.C.E., Engineer in Chief of Victorian Railways, that his Government considered it desirable that he should visit Europe and America, inspect the railways of those countries, and prepare a report concerning them for the information of the Australian Government. Accordingly Mr. Higinbotham left Melbourne on the 10th of March, 1874, and visited America, Great Britain, Europe, and returning by way of India, inspected most of the great lines in that country. He arrived in Melbourne again on the 11th of January, 1876, having thus been absent a year and ten months. During his tour Mr. Higinbotham met everywhere with the utmost courtesy. He was freely supplied with information, and he learned a great deal. This information he has embodied in a very terse and ably written report of seventy-two large pages, and it is with this report on the railways of the world that we now propose to deal. It will be understood at the outset that there are multitudes of questions connected with the working of railways with which Mr. Higinbotham did not concern himself. The paramount object he had in view was to collect data which would be useful in Australia. But he has done more than this, for he has contrived to put into his report a summary description of the railways of the world which contains a very considerable mass of general information, rendering the paper one of the most valuable contributions to the literature of railways ever penned. We do not propose here to go fully into Mr. Higinbotham's report; for the present we shall content ourselves with dealing with some of the facts he places before his readers. Mr. Higinbotham went first to the United States. He reached San Francisco on the 14th of April, 1874, and his first stopping place was Sacramento City, where he inspected the workshops of the Central Pacific line. Of this road at the time there were 1,600 miles open; the main line from San Francisco to Ogden, where the Union Pacific line begins, being 882 miles long. Mr. Higinbotham deals tenderly with the shortcomings of this railway, while he describes its general characteristics very succinctly. We have not space to reproduce in full his description of the rolling stock; it must suffice to say that the engines are all fitted with bogies, or "track feelers," as they are expressively termed, which carry from 30 to 40 per cent. of the whole weight of the engine. The passenger engines weigh with steam up about 33 tons; they have 17 in. cylinders, 24 in. stroke, and four coupled drivers 4 ft. 8 in. to 5 ft. in diameter; the tenders weigh full 25 tons. The heaviest gradient worked is one in fifty over the Sierra Nevada. Three engines are required to take up a train of nine or ten passenger cars. These cars each weigh about 13 tons, of which the two bogies represent about 5·5 tons. They seat fifty-two, and when the car is full the dead weight per passenger is 754 lbs. Mr. Higinbotham gives similar particulars of all the lines with which he deals. Sometimes the details are better filled in, sometimes the information is more meagre; but, on the whole, he supplies just what is wanted. We shall not attempt to follow him step by step. It will be of more interest to our readers to learn something concerning the opinions of a competent engineer, who has had innumerable opportunities of acquiring information. Mr. Higinbotham has a good deal to say, for example, concerning a much vexed question, namely, the relative merits of English and American locomotives, and we shall confine our attention to this branch of the subject for the moment.

AMERICAN VS. ENGLISH LOCOMOTIVES.

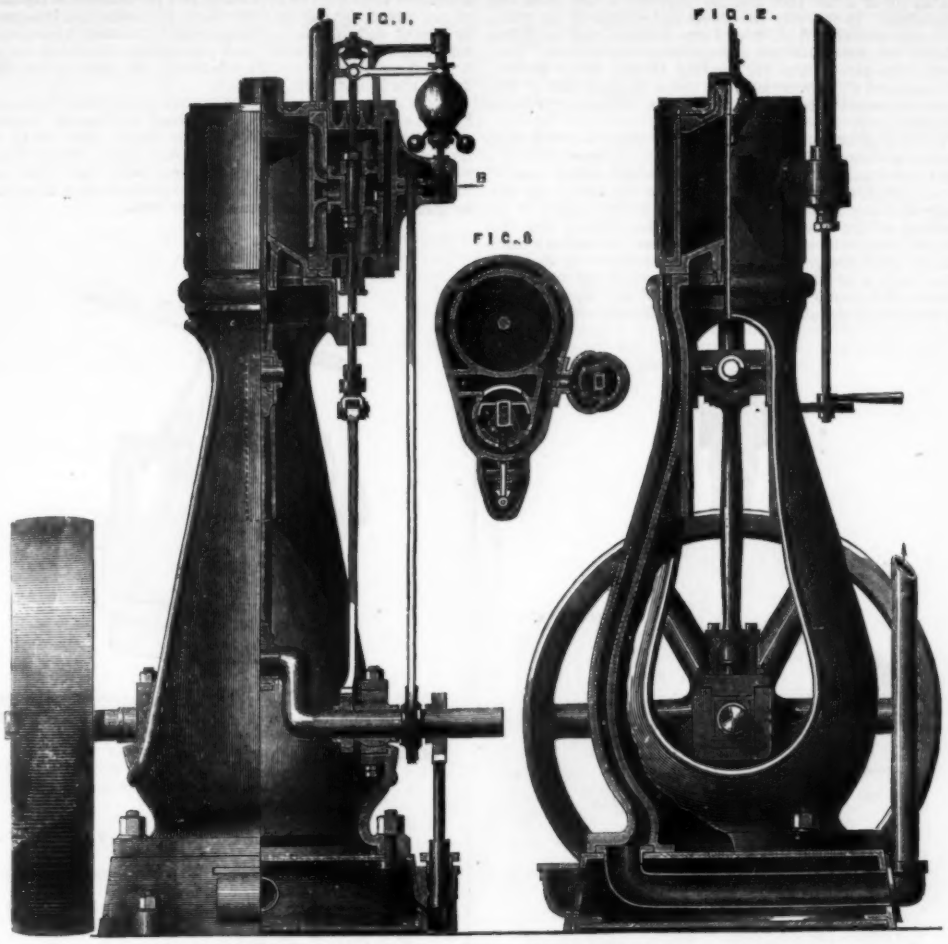
It has often been stated in England, as well as in the United States, that the American locomotive is cheaper to build, to maintain, and to work than the English engine, and the statement has been disputed as often as it has been made. Mr. Higinbotham reports that all the evidence he has obtained goes to show that on bad roads, such as exist in the United States, English locomotives could not be used at all; from which it appears that the American engine has a distinct vocation, and that it is vain to draw comparisons between the two types of machine. In writing about the Pacific Railroad, for example, Mr. Higinbotham says: "I had opportunities of speaking to several drivers, Englishmen, who had driven in England; they all preferred the American to the English engine, which, they said, could not keep on such roads as are commonly to be found in the Western States." This may be taken as unprejudiced testimony: "The road was rough, and the speed at times down falling gradients very great, but the drivers appeared to have perfect confidence that their engines would not leave the road. The bogie they consider the great source of safety." It may be said that as these men had not tried English engines on the road they could not speak from experience. In his account of the Grand Trunk of Canada Railway, however, he subsequently says: "The whole of the engines and rolling stock first put on the line were built in England, but the engines were constantly getting off the road, and engines and cars of every class are now of the same kind as those in the States." Further on we read: "The bogie truck and cast iron wheels are two of the most important features of American engines and rolling stock, and both of these appear to me to have been adopted in consequence of the very imperfect permanent way and the great severity of the climate in winter, when the road bed, which is frequently formed of earth only, is exposed alternately to intense frosts and sudden thaws, which completely distort the track. Only bogie engines and rolling stock could live on such roads, as was proved in the case of the Grand Trunk Railway of Canada, where, neglecting the experience that had been gained in the States, and relying also, no doubt, on a better and more carefully laid road than was to be found there, English engines and rolling stock were tried, but had to be abandoned, and the American type adopted. Very recently the same mistake was made on the narrow gauge railroads in Canada, and with the same result." We cannot ignore testimony of this kind, and it may be taken as conclusively settled that bogie engines, and American bogie engines in particular, are less likely to be thrown off a road than English engines. This result is due, no doubt, to two causes. The first is the comparative flexibility of the American engine, the whole wheel base of which can twist itself so as to follow the vertical or horizontal contortions of a road with great ease; while the second is that the leading wheels of the American engine bogie are left very much to themselves, and are but little exposed to the influence of the lateral motion of the engine.—*The Engineer.*

VERTICAL ENGINE AND EXPANSION GEAR.

WE illustrate an arrangement of vertical engine fitted with a form of balanced slide valve, which has been designed by G. W. Weatherbogg, London, and which includes some features deserving notice. The standard of the engine is of curved cylindrical form, having suitable openings formed in each side to allow access to the working parts. It is bolted upon a separate square or cylindrical casting, which forms a water base through which the exhaust steam is passed for heating the feed water.

The crankshaft works in universal bearings, the construction of which is somewhat novel. The outer frames of the bearings are cast on the standard and have adjusting pieces with screwed ends, which pass through the standard and are held in position by lock nuts. A similar upper adjusting piece is also made to slide within the frames. Both the top and bottom pieces are cylindrical on one side and fit upon the gun-metal bearings, the whole being held down by a cap-piece and studs in the usual manner. The bearings are made somewhat less than the inner sides of the frames, which permits of the crankshaft working out of line without heating.

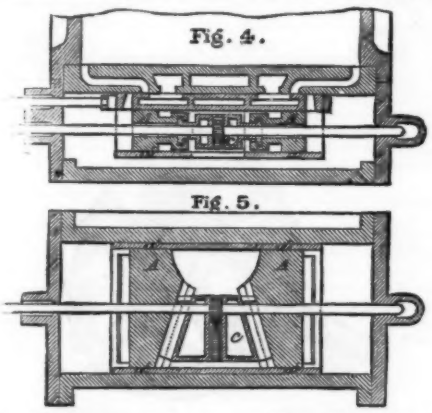
One other peculiarity in the engine is the slide valve, which is perfectly balanced under all pressures; it is readily adjusted, and will, without the aid of cylinder cocks, relieve the cylinder from any back pressure occasioned by priming, the balancing being accomplished by the application of a wedge formed on the valve spindle. The steam chest is cylindrical and steam jacketed along with the cylinder. The slide valve has two segmental faces turned to fit the chest; one face works upon the passages in the usual manner, whilst the other forms the balance and regulating plate, by the use of which the throttle valve is dispensed with. Steam is taken direct through an opening in the center of the steam chest from the boiler, and passes through an elongated opening in the balancing plate. The valve spindle passes through the upper end of the steam chest, and is connected to the governor lever by gearing as shown, which gives a slight rotation to the valve and balancing plates sufficient to regulate the admission of steam to the cylinder. The rotating motion given to the valve prevents cutting of the valve faces, and gives a smooth glassy surface to the



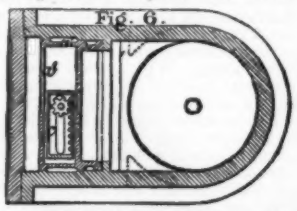
VERTICAL ENGINE AND EXPANSION GEAR.

valve and cylinder facings. A center weight quick-speed gov- nor is used, the standard for it being cast on the steam chest.

We also illustrate by Figs. 4, 5, and 6 an arrangement of expansion valves which consists in using two cut-off plates,



A, placed on the back of an ordinary slide valve, the er having straight steam passages of the usual form. The off plates move in a line parallel to the valve spindle, and are prevented from having any lateral motion by stop plates or guide frames, formed on the back of the main valve. The plates are connected together by means of a hollow T-ended wedge or cone C, which slides in channels or grooves cut in the plates. Upon the cut-off valve spindle is keyed a pinion gearing into a rack cast on the inner side of the wedge or cone. The pinion serves as a driver for the cut-off plates, and also has a slight turning motion along with the valve spindle imparted to it by the action of the governor,



which causes the cut-off plates to be drawn towards or recede from each other, by which means the steam is cut off earlier or later, according to the purposes for which it is needed. The plates working in the guide frames, as shown, have a provision made for wear, and are nearly in equilibrium (a great desideratum towards obtaining a quick and sensitive action), and may be constructed to cut off the supply of steam either with their inner or outer edges. When the former plan is adopted the T-ends of the wedge slide in grooves cut through the center of the valves. It will also be readily seen that this method, occupying but little space, is equally applicable to double-cylinder engines. —*Engineering.*

MANUFACTURE OF PEAT STEEL.

The advantage to be anticipated from the adoption of peat fuel in the manufacture of steel, provided such fuel can be produced of sufficient density and at a moderate price, is generally admitted in the iron trade; and it appears that by Mr. Dodge's process, recently introduced in America, solidity and cheapness are simultaneously secured. The number of peat condensing and peat compressing processes are very large; but although many of them have appeared theoretically perfect, and some have so far succeeded in practice as to enable a considerable quantity of the fuel to be brought into the market, it has always been found that the success was merely temporary, the use of some particular quality of peat not readily procurable being essential, or the machinery suffering so severely from wear and tear as to make the continued manufacture unremunerative. From one cause or another even the best of the processes have one by one fallen into disuse, but it is believed by those who have had full opportunity of judging that the success of the Dodge process will prove permanent.

In many parts of the United States rich peat is found in great abundance, and the utilization and development of one of these is at the present time being successfully carried on at the Syracuse Peat Works, in Clay, Onondago county, New York. Mr. James M. Hart, of Oswego, has forwarded samples of the condensed peat to the *Mining Journal* office, and they are well worthy of inspection. To judge from the samples, the raw peat operated upon was by no means exceptionally heavy, nor particularly free from strong fibre, which has hitherto been the leading difficulty, yet the condensed fuel is so compact as to leave a close and finely polished surface when cut with a penknife. The condensed peat is being largely used in Syracuse for domestic purposes, and particularly as a fuel for cooking stoves and ranges, the price, delivered to the consumer, being $4.50 per ton. The new fuel appears to be giving great satisfaction, for many consecutive orders have been received from the same customers, and the number of consumers is constantly increasing. At the works at Clay, where the Dodge process is in full operation, they can run through the machine 1 ton of crude peat per minute, and deposit it in drying beds; it requires 6 tons of crude to give 1 ton of solid peat in crits ready for use, so that they could produce 10 tons of condensed peat per hour, or 100 tons daily, if prepared to handle it.—*London Mining Journal.*

HAUCTIN'S PULVERIZING MILL.

THE pulverizing mill of Hauctin, of St. Denis, consists of a cylindrical drum, which is closed at both ends, and provided with no interior revolving cylinder. The revolving cylinder has a number of holes in which solid balls are seated. The circumference of each hole or seat is curved, and of a radius somewhat larger than that of the balls. These ball bearings are arranged on the circumference of the cylinder in the line of a slowly rising spiral. At both heads of the outer drum are cross-pieces with lubricated bearings, in which the shaft of the inner cylinder turns, while the heads are fitted tightly to the shaft by rubber packing rings. In smaller drums the bearings and stuffing boxes are arranged directly with heads. The material is conveyed to the pulverizer by a top hopper at one end, and discharged by a swinging door at the other lower end. The apparatus is supported on standards and inclined slightly towards the discharge opening.

The distance of the outer cylinder from the revolving cylinder is such that the balls can never entirely leave the inner cylinder, and are therefore compelled to follow the rotating motion of the same. On the lower half of their way, they roll along the inner surface of the outer drum, until gradually raised again by the inner cylinder, and, when arriving near the top, taken up by the holes of the same. The material to be pulverized is introduced between the outer and inner cylinders, and acted upon by the balls rolling over the same in the lower part of the apparatus. The inclined position of the apparatus and the spirally arranged position of the balls feeds the pulverized material gradually towards the discharge opening. The number of balls, and arrangement of the same in a spiral of slight inclination, produces the action of the balls on every point of the inner surface of the outer cylinder during the rotations of the inner cylinder. The apparatus is mainly intended for the pulverizing of charcoal for foundries; of sugar for the manufacture of chocolate, and for similar purposes; producing, by a single passage through the apparatus, a powder that suffices for most purposes, and which becomes impalpable by being passed a second time through the same.

HAUCTIN'S PULVERIZING MILL.

THE INTERNATIONAL EXHIBITION OF 1876.

TESTS OF TURBINE WATER WHEELS.

[Continued from page 999.]

One of the pumps which supplied the water to the overhead tank was an entirely new one, patented in 1876 by Mr. Wm. D. Andrews, and called the "Cataract Centrifugal Pump," and it was shown here for the first time. There are several quite novel features in it, which will be seen upon reference to Figs. 8 to 16 inclusive.

This variety of pump is designed for use in wrecking, irrigation, and for all purposes where large volumes of water require to be lifted through moderate heights, and there is probably no machine in use to-day which is subjected to such severe duty, or required to perform under so many diverse and abnormal conditions as the centrifugal pumps. It is expected of them that they will lift and discharge with the water, sticks, stones, gravel, sand, grain, and all kinds of heterogeneous *debris;* then they are required to stand in all possible positions, and to be able to conform to these with facility, and in situations which will not permit of anything more than the crudest kind of preparation. They are to be tossed and bundled about from place to place, subjected to the roughest possible usage, and when in place are often put to the severest strain; and unless they are competent to

Fig. 8.

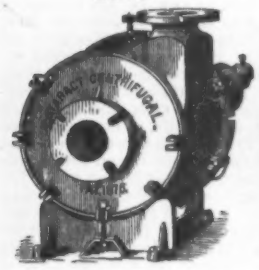
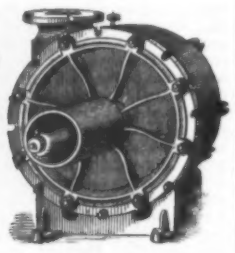


Fig. 9.



stand all this, and to hold out at the critical time, large values may be swamped through their failure. An inspection of this pump will show that much care has been had to meet all these demands.

It is entirely new in style, shape and fittings, in the manner of utilizing the centrifugal force, in the manner of setting and changing the direction of the discharge without using bends, in the unusually large size of the passages through it, and in the facility with which the various parts may be removed and replaced, without disturbing the driving gear, suction or discharge pipes.

Unlike centrifugal pumps generally, there is no outer water passage encircling the disc or wheel, which permits of a smaller diameter of pump, reduces the number of revolutions required for a given work, and cheapens the whole in both labor and material. The opening from the wheel to the discharge being the full width and size of the attached pipes, and the inner ends of the wheel arms terminating at the outer diameter of the suction opening, no obstruction is offered to the passage through the pump of any substance which can enter the pipes; so that, in dredging and wrecking operations, that most troublous of all troublesome things, a strainer on the suction pipe, is entirely dispensed with.

The method adopted to provide for a change in direction of the delivery pipe, without resorting to bends and

Fig. 10.

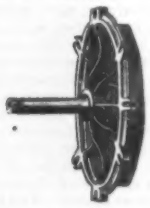


Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 16.

elbows in the pipe, is a most felicitous one. Fig. 16 shows the bed piece in which the cylindrical pump case lies, bearing on either side on three points. On the driving side, as shown in Figs. 9, 10 and 16, are slotted bolt holes in the bed and flange of the pump case, and slotted lugs on the removable head, regularly divided in the circle so that any three of the one will correspond in position to those of the other. On the suction side, as shown in Fig. 8, similar lugs are cast on the case made to receive a single vertical bolt; the four bolts shown in position in Fig. 16 serving to secure the case to the bed in either of six different positions, as may be desired, the entire pump being simply turned upon its axis into the desired position. This system of slotted bolt holes is adopted on all flanges upon the pump, they being given the additional strength necessary. In connection with this is the plan of securing the bolts at their places by small chains; and as by the use of these slots the nuts never require to be removed from the bolts, this constitutes a very simple and excellent means of providing against the annoyance of loss of these things in the turmoil incident to such operations as wrecking, dredging, etc., where it is so likely to occur; while the large amount of time saved in making the different changes and adjustments will be apparent to any one who has had occasion to try to enter a number of nuts upon bolt ends in a hurry, or under wet, stormy, or other difficult conditions.

On the head, Fig. 20, is cast a long hub or sleeve, within which the shaft of the wheel, Fig. 22, runs. Upon this sleeve the clutch, Fig. 15, runs, passing over a packing nut, Fig. 13, and being secured to the wheel shaft by a set screw, as seen in Figs. 9 and 15. The pulley, Fig. 14, engages with this clutch, and thus imparts motion to the wheel. With this construction it will be seen that a good long bearing is given to the wheel shaft, dispensing with an outer bearing, while the whole may be removed by the simple slacking up of a few nuts and the slipping of the bolts out of the slots. In this way the wheel and interior of the pump may be examined in from five to ten minutes, and anything replaced without disturbing a single pipe connection. This construction also insures the bearing always being in line, and precludes all liability of their being strained out of line by inexperienced workmen, or from the weight or pressure from pipes, etc.

The form of the arms or wings of the wheel are such as to give to the water, first, an easy motion, compounded of a radial and a tangential course, while the true radial lines of the extremities of the arms deliver the water into the discharge opening, at as nearly as possible a true tangent to the periphery of the wheel. Experiment has shown that this form of wing will deliver under a given head with a minimum of revolutions. The many novel features in this machine marks a decided advance in the centrifugal pump.

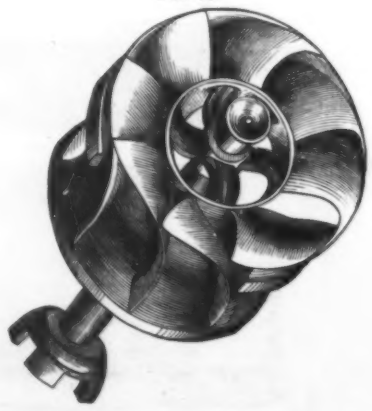
Before the commencement of a test of the water wheels, the watches of the attendants at the different stations were

Fig. 17.

set to correspond. All necessary preparatory running of the wheels was had before the beginning of a test, to insure that everything was in proper order, and this was always made dependent upon the exhibitor's own decision as to when these conditions were reached. With a wheel running under the weight, revolutions, fraction of gate, etc., as chosen by its owner, and all in a normal state of operation, the timings were made by a bell signal which could be heard by all the attendants, they relying upon their watches for a determination of fractional periods of a run, as was the case with all records except the revolutions. All the tests were made under practically similar conditions, and the notebooks of the several attendants were compared and copied at the conclusion of each test. What amounted to an experimental test was had with each wheel before beginning the test proper, to insure that the apparatus was in correct working order. The fraction of gate and duration of test as well as the other conditions was as chosen by the exhibitor, and he was allowed to make examination of the wheel and apparatus at the conclusion of each test.

The water used in lubrication, carrying off the heat, and that which leaked about the setting of the wheel, was care-

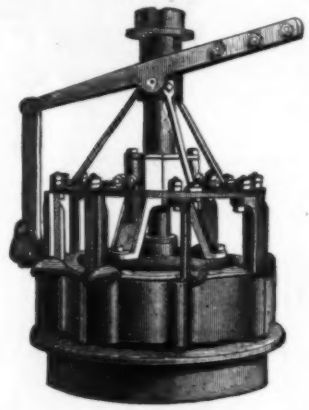
Fig. 18.



fully measured by means of a wheel having gates somewhat in the form of plug cocks and known to be tight, by the flow over the weir with these gates shut. In this way the leakage of gates themselves, which in some of the wheels was considerable, was eliminated, as it properly should be, inasmuch as this latter leakage is utilized in the running of the wheel, and would not appear with the gates open, except at partial gate; and even then such leakage should be charged against the wheel. As the wheels were all set in the same way, it was presumed that all leakage not through the wheel itself would be practically equal to that determined by the trial with the tight gate wheel with closed gates. During the first six trials the leakage was very considerable, and amounted to as high as 53.4 cubic feet per minute in the case of one wheel; by the time the sixth test was had, however, by dint of calking and packing around the leaky places, this was reduced to 14.35 cubic feet per minute, at which figure it was thereafter taken. That is to say, the head on the weir due to the leakage was .040 feet.

In the determination of the theoretical power of the water I have used the coefficients determined by Francis' experiments at Lowell; the coefficient for heads from .03 to .30 feet being 3.41, and thence to 2.00 feet, 3.33. There being contraction at both ends of the vein with this weir, the virtual length of vein I have gotten by subtracting from the length of opening $\frac{2}{10}$ the head on the weir.

Fig. 19.



The flow from leakage I have calculated in the same way. The rule used may be expressed in the following formula:

Let H = Head of water on wheel, in feet.
h = Head of water on weir, due to total flow, in feet.
h_1 = Head of water on weir, due to leakage, in feet.
HP^1 = Horse power of wheel.
P = Percentage of efficiency.
F = Cubic feet of water per second of total flow over weir.
f = Cubic feet of water per second due to leakage.
L = Length of weir opening in feet.
w = Weight of a cubic foot of water in lbs., and
C = Francis' coefficient for the given head, then

$$F = C\sqrt{h^3}\,(L - \tfrac{2}{10}\,h) \quad \ldots\ldots 1$$

$$f = C\sqrt{h^3}\,(L - \tfrac{2}{10}\,h_1) \quad \ldots\ldots 2$$

Or substituting for $\sqrt{h^3}$ and $C\sqrt{h^3}$ the values given in Francis' table, and calling them respectively V and v, we have:

$$F = V\,(L - \tfrac{2}{10}\,h) \quad \ldots\ldots 3$$

$$f = v\,(L - \tfrac{2}{10}\,h_1) \quad \ldots\ldots 4$$

and for the horse power of the water:

$$HP^1 = \frac{w\,H\,[V\,(L - \frac{2}{10}h) - v\,(L - \frac{2}{10}h_1)]}{550} \quad \ldots\ldots 5$$

and

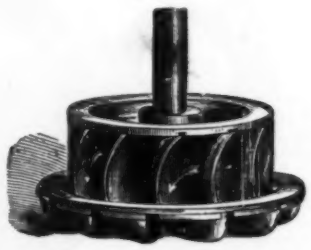
$$P = \frac{55000\,H\,P}{[v\,(L - \frac{2}{10}\,h) - v\,(L - \frac{2}{10}\,h_1)]} = \frac{100\,HP}{HP^1} \quad \ldots\ldots 6$$

Fig. 20.

From equations 3, 4, 5 and 6, I have computed the values in columns 60 F, 60 f, HP^1 and P in the table, for the best two minutes' run at each setting of gate for each wheel. The fraction of gate given in that column is that designated by the exhibitor; but it will be seen upon inspection of column 60 F that in many cases it is very far from expressing the true proportion of water used.

I could not find that the temperature of the water was noted, and have therefore taken throughout w = 62.3 as a

Fig. 21.



probable mean weight of a cubic foot of water through a period lasting from Sept. 21st to Nov. 10th.

The tests were made under the supervision of Mr. John Cotter, engineer in charge of Hydraulic Section, Machinery Hall, by Mr. Samuel Webber, assisted by Messrs. P. R. Voorhees, Percy A. Sanguinetti and Samuel Webber, Jr. Mr. Webber was appointed to conduct the tests by the chief of the Bureau of Machinery, with the consent of all the exhibitors.

The wheels of the following exhibitors were tested:

T. H. Risdon & Co., Mount Holly, N. J.; Knowlton & Dolan, Logansport, Ind. (Obenchain's patent); John T. Noye & Sons, Buffalo, N. Y. (tested twice); A. N. Wolff, Allen

town, Pa. (tested twice); Barber & Harris, Medford, Ont., Canada (Barber's patent); Goldie & McCulloch, Galt, Ont., Canada; Putnam Machine Co., Fitchburg, Mass. (two tests; Tyler's patent); W. F. Mosser & Co., Allentown, Pa.; O. J. Bollinger for York Mfg. Co., York, Pa. (Bollinger's patents; three tests); Thos. Tait, Rochester, N Y. (Tait's patent; called the Centennial wheel); National Wheel Co., Bristol, Conn. (Case's patent); E. T. Cope & Sons, Westchester, Pa.; Rodney Hunt Machine Co., Orange, Mass. (Swain's patent bucket); Stout, Mills & Temple, Dayton, O. (American Turbine Co.); R. D. Wood & Co., Phila., Penn. (Geyelin's patent wheels; three tests); and Chase Turbine Mfg. Co., Orange, Mass.

The York Mfg. Co.'s third test was made solely with the view of ascertaining the value of shallow buckets and the central discharge, and is therefore not to be considered as a competing wheel. It may also be said, in extenuation of the results with the Geyelin wheel tested for R. D. Wood & Co., that it was too tightly fitted in the shop to run under the head of water put upon it; and, after several attempts to ease it, it was finally withdrawn. E. T. Cope & Sons' wheel was also too nicely fitted to run well under this head. The National Wheel Co., too, declined to make any part gate test for the reason that the wheel bound in the case. The Tyler wheel, tested for the Putnam Machine Co., appeared to be loose in the upper bearing, which may have affected its proper working. The Cope and Hunt wheels labored under some disadvantage, from the fact that the supply of water was barely adequate to their demands. The tests of the Tait wheel were quite exhaustive, as will be seen upon inspection of the table; and served to show that the weir measurements were entirely competent to indicate correct results for small variations in the head of water upon it, or in the load and revolutions.

The six wheels which are among the highest examples of efficiency are given in the figures 17 to 30 inclusive.

Fig. 17 is a perspective view of the Risdon turbine, and Fig. 18 the wheel proper, with a portion of the lower band removed to exhibit the form of the band and buckets. The wheel is designed to receive the water without shock, and to release the step from the pressure of the column of water upon it, by receiving it under the curved top flange, as shown in Fig. 18. The object of the band is to both strengthen the wheel and to give the proper form to the issues, confining the water on all sides within the structure of the wheel itself. The gate of this wheel is of the cylinder kind; being raised and lowered by means of a rack upon the hub, from which three arms extend to its top edge. The crown plate of the wheel not seen in the figure, as the gate is shown at its highest place, is placed close to the top of the wheel, and is supported by three inverted U-shaped pieces secured to the top of the guides, within which the gate rises. The outer edge of the crown plate fits the inner side of the cylinder gate and guides the gate closely to the wheel, and prevents the gate and wheel from binding or coming in contact, and permits of a flexible packing ring at the top of the crown plate bearing against the inside of the gate, insuring perfect tightness at that place. A long perpendicular hub from the crown plate supports the shaft.

Attached to the outer side of the gate is what may be regarded as a rim, through which slots are made for the passage of the guides as the gate is moved up or down upon them; constituting really a series of projections whose lateral form and dimensions are that of the spaces between the guides. Vertically they are wedge-shaped, being inclined at the top to prevent the lodgment of obstructions upon them, and on the bottom to give the proper form of adjutage, such as to admit the water to the wheel practically as correct for a partial as for full gate; while this form permits of these projections having the necessary strength throughout. This seems to be a most admirable arrangement, and doubtless accounts for the very excellent part gate results obtained from it.

At the first runs of this wheel the data was such as to indicate an efficiency of 90.54 per cent., the horse-power of the wheel being 85.42. The latter figure was allowed to stand, and was credited to the wheel; the percentage was not, however, as there was thought to be some uncertainty as to the entire reliability of the readings for the depth on the weir.

From inspection of the table, it will be seen that this wheel reachest the highest efficiency of any on trial, and not only does it attain to this coveted position under a full gate, but its performance under partial gate occupies fully as high a place among the competing wheels. It appears that if the greatest flow over weir, given in the runs which were allowed, were charged against the 85.42 horse-power run of wheel, the efficiecy of over 90 per cent. would be obtained, and the exhibitor thinks it should therefore have been allowed him.

Figs. 19 to 24, inclusive, show the wheel of Knowlton & Dolan, in which there are some remarkably fine points. It may be said of the results in this case, as given in the table, that they would possibly have been higher had the wheel been run at a different speed.

In the table given by the manufacturers, they claim the highest efficiency under the head used, at a lesser number of revolutions, and they appear to have been somewhat remiss in failing to see that their wheel was not run under what they claim as the best attainable conditions.

FIG. 23.

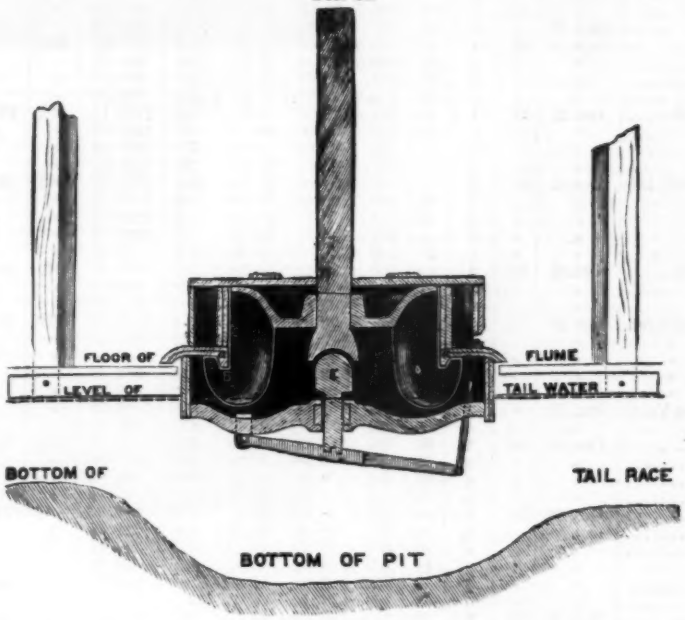


FIG. 23.

FIG. 24.

Fig. 19 shows this wheel complete and ready to be put in the fore-bay. In reducing gate, it will be seen that the adjutages are reduced in vertical dimensions only, by vertically sliding gates, preserving the form of adjutage uniform. In effect upon the water vein this arrangement is very similar to the gate of Risdon & Co., and goes to show that the principle is a good one; as in this case, too, the part gate results bear a high proportion to those at full gate. Figs 20 and 21 are the wheel proper; the form of the buckets are peculiar, and the curving form of the body of the wheel from the upper flange inward, together with the curving forward of the upper ends of the buckets, forms a chamber which must receive the water easily and without shock; as well as to relieve the step of the hydrostatic column to a very great extent. In Fig. 22 is shown a very felicitious contrivance for preventing leakage between the wheel and the case, and providing for an adjustment of the joints for an indefinite time; obviating the loss of water by wear in the joint from gritty water as the wheel is continued in use. A is a flange or bead, cast in the case, just outside the circumference of the wheel, projecting downward into a groove, B, formed between the outer upright edge of the bucket, C, and the wrought iron ring, D; which is riveted to the horizontal lips on the outside or centrifugal discharge of the buckets. This bead and groove are conveniently adjusted to each other at a moment's notice, by means of the screw and lever, F, which raises or lowers the adjustable step, E. This adjustment may be made even after the wheel has been in use for years, restoring it to its original tightness at any time.

FIG. 25.

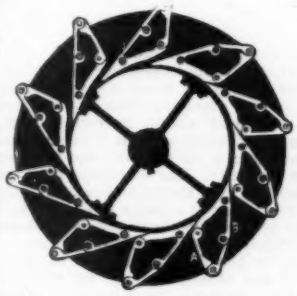


FIG. 26.

This is a very simple and effective contrivance, and must add much to the value of the wheel. Another very excellent device is seen in Figs. 23 and 24. This consists in a ratchet coupling, which will be readily understood upon reference to the figures. This coupling occupies the point in the vertical shaft at which the wheel shaft is connected to the extension of it, and permits of the rotation of the wheel being suddenly arrested—as often happens from the passage of obstructions through the gates—without any injury to it; the machinery in such a case continuing to run by its accumulated momentum by the three parols shown in Fig. 23, passing by the stop shown on the inside of Fig. 24; whereas a rigid connection would be likely in such an event to result in fracture of some part of the wheel or case. The parols shown in Fig. 23 are forced outward against the inside of the cup, Fig. 24, by springs not seen.

Another quite strong point in this wheel is that the power developed by it, in proportion to its diameter, exceeds that of any wheel on the list, except that of the Rodney Hunt Co., and in many cases it is greater than that developed by a much larger wheel, so that, everything considered, these exhibitors may be congratulated upon their record.

FIG. 27.

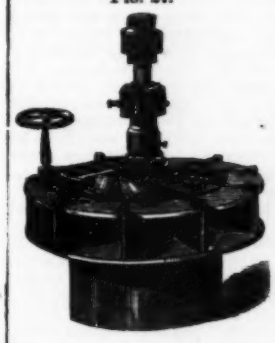


FIG. 28.

Figs. 25, 26 and 27 represent the wheel of Thos. Tait, the first being an horizontal section through the guides, the second a perspective view of the wheel proper, and the last the case and wheel complete. In Fig. 25 five of the guides are shown partly open and five shut. Each guide is formed of four pieces jointed at the points indicated by the small circles. They form, when open, nearly a triangle, and when closed a lozenge-shaped outline. The inner part of that which constitutes the longest side of the triangle when open, is stationary, and forms columns of support between the top and bottom plates which constitute the upper and lower limits of the adjutages. The outer joint in each is connected to a bar leading to the usual ring upon the upper side of the wheel case, operated by an arm, segment and pinion. The effect of moving these outer ends of the guides for closing, is to bring the heel part of the curved side of the triangle—that which lies next the periphery of the wheel—down upon the point of the stationary part of the guide immediately behind it; and its principal advantage appears to be that it closes the adjutage, or cuts off the water very close to the periphery of the wheel, preventing the spreading of the vein after passing the gate and before impact upon the wheel, tending toward that desideratum, an improved efficiency at part gate. This gate has the merit of being easily removed, one, or a part of one, without the other; and, as these pieces are all made to uniform dimensions, the replacement of a broken one occupies but a few minutes. This wheel was originally run with a form of cylinder gate, and has been increased in efficiency a large percentage by the substitution of this gate. In Fig. 26, the band surrounding the lower ends of the buckets meets a ring in the top of the curb, making a joint of considerable surface to prevent leakage between the wheel and the case. The ring is loose and may be renewed at any time. As will be seen on reference to the table, this wheel was submitted to a more exhaustive test as to performance under partial gate than either of the

FIG. 29.

TABLE SHOWING BEST TWO-MINUTE RUN FOR EACH WHEEL FOR EACH FRACTION OF GATE USED.

Name of Exhibitor.	Date of Test.	Diam. of Wheel.	Fraction of Gate.	W—Weight on scale, in pounds.	R — Revolutions per minute.	PP — Horse power of wheel.	H—Head on wheel, in feet.	h_1 — Head on weir, in feet.	Q F— Flow over weir, in cubic feet per minute.	h_2 — Head on weir, due to leakage, in feet.	Q f — Flow due to leakage, in cubic feet, per minute.	HP' — Horse power of water.	P — Per cent. of efficiency.
T. H. Risdon	Sept. 21	30″	1	78	266	82.99	30.36	.973	1688.83	.072	34.66	94.78	87.56
" "	"	"	¾	68	257	69.90	30.59	.874	1440 75	"	"	81 20	86.20
" "	"	"	½	58	248	57.53	30.84	.787	1233 48	"	"	69.73	82.66
" "	"	"	¼	41	258	42.31	31.00	.681	965 26	"	"	56.22	75.26
Knowlton & Dolan	Sept. 28	36″	1	50	333.5	66.70	30.81	.908	1524 42	.082	42.15	86.22	77.36
" "	"	"	¾	48	299.5	57 50	30.85	.853	1389.78	"	"	78 46	73.29
" "	"	"	½ to ¼	38	233	35.41	31.18	.684	1001.76	"	"	56.49	62.69
John T. Noye & Sons	Sept. 26	26″	1	34	269	36 58	31 10	.698	1032 30	.072	34.66	58.57	62.45
" " "			¾	26	317	32.96	31.16	.630	859.39	"	"	50 55	65 20
" " "			½	26	289	30 05	31 24	.620	865.24	"	"	49 01	61 31
" " "	"	"	¼	22	203	25.78	31.29	.542	708.85	"	"	39.74	64.87
" " "	"	"	¼	20	265.5	20.52	31 28	.536	697.20	"	"	39 12	53.45
" " "	Sept 27	"	1	28	317	35.50	30.95	.665	900.72	"	"	54.11	65.61
Barber & Harris	Sept. 18	20″	1	28	330.5	37.01	31 18	.626	872.22	.096	53.40	48.53	76.23
" "	"	"	¾	22	380.5	33.48	31 27	.600	824.52	"	"	45.52	73.55
" "	"	"	½	20	299	23 92	31.45	.495	619.32	"	"	33 60	71.19
" "	"	"	¼	16	271.5	17.37	31.62	.405	459.30	"	"	24.23	71.68
Goldie & McCulloch	Oct. 2	27″	1	70	281.5	78.82	30 05	.988	1727.10	.072	34.66	96.01	82.00
" "	"	"	¾	50	280	56.00	30.14	.858	1401.84	"	"	77 79	71.99
" "	"	"	½	30	350	42 00	30.55	.850	1382 52	"	"	77.73	54.03
" "	"	"	¼	30	335	39.00	30.65	.782	1221 90	"	"	68.70	58.22
Putnam Mach. Co. (Tyler)	Oct. 4	30″	1	72	257	74 01	30.05	.960	1655.28	.040	14.35	93.09	79.50
" " " "	"	"	¾	58	286.5	66.46	30 10	.880	1455.48	"	"	81 29	81.75
" " " "	"	"	½	56	261	58.46	30.25	.814	1296.72	"	"	73.23	79.83
" " " "	"	"	¼	44	247	43 47	30.60	.745	1137 12	"	"	64.86	67 02
" " " "	"	"	¼	36	240	34.56	30.80	.622	869.80	"	"	49.73	69.49
W. F. Mosser & Co	Oct. 6	24″	1	42	300	50.40	30.56	.763	1178 15	.040	14.35	67.20	75.00
" " "	"	"	¾ to ½	32	310 5	39.74	30.90	.666	962.88	"	"	55.38	71.82
" " "	"	"	¼	26	347	36.08	31.02	.644	916.02	"	"	52.80	68.33
York M'f'g Co. (Bollinger)	Oct. 12	27	1	54	246.5	53.24	30.42	.804	1273.14	.040	14.35	72.29	73.65
" " "	"	"	¾	36	300	43 20	30 60	.742	1130.34	"	"	64.45	67 08
" " "	"	"	½	36	280	40.32	30.70	.708	1043.34	"	"	59.64	67.61
" " "	"	"	¼	34	268	36 44	30.85	.656	941.46	"	"	53.99	67.49
" " "	"	"	¼	26	285	29.64	31.08	.603	830.70	"	"	49.45	59.94
" " (Centre Vent)	Oct. 13	"	1	56	235	52 64	29 86	.860	1406 70	"	"	78 49	67.07
" " "	"	"	½	36	233	33.55	30.46	.672	975 78	"	"	55.28	60.69
A. N. Wolff	Oct. 15	24″	1	50	320	64.00	30.16	.905	1516.98	.040	14.35	85.54	74.82
" "	"	"	¾	52	307.5	63.96	30.14	.909	1526.94	"	"	86.07	74.31
" "	"	"	½	30	284	34.08	30.83	.644	916.02	"	"	52.48	64 94
" "	"	"	¼	26	271	28 18	30.90	.588	800.16	"	"	45.84	61.47
Thos. Tait	Oct. 23	25″	1	40	288.5	46.16	31 00	.672	975.78	.040	14.35	56.27	82.03
" "	"		¾	26	292	30 37	31.32	.548	720.74	"	"	41.76	72.72
" "	"		½	22	258	22 70	31.44	.480	585.60	"	"	33.91	66.94
" "	"	"	½	12	265	12.72	31.47	.373	406.26	"	"	23.28	54.64
" "	"	"	¼	8	235	7.52	31 59	.309	307.26	"	"	17.47	43.05
" "	"	"	¼	6	266	6.38	31 61	.303	297 90	"	"	16 92	37.71
National Wheel Co	Oct. 18	25″	1	56	279	62 49	30.17	.826	1325.16	.040	14.35	74.66	83.70
E. T. Copee & Sons	Oct. 19	30″	1	80	241	77.12	28.80	1.040	1863.06	.040	14.35	100.51	76 72
Rodney Hunt Mach. Co.	Nov. 9	24″	1	72	276	79 48	29.25	1.038	1857.78	.040	14.35	101.79	78.08
" " " "	"	"	¾	40	312	49.42	30 25	.809	1284.96	"	"	72 56	68.79
" " " "	"	"	½	58	289	67 04	29.60	.974	1690 92	"	"	93.69	71.55
" " " "	"	"	¼	34	238	32 37	30 44	.743	1132 62	"	"	64.26	50.35
Stout, Mills & Temple	Nov. 10	30″	1	70	231	64.68	29.55	.980	1706.52	.040	14.35	94.40	68.50
" " "	"	"	¾	58	230	53.36	29.38	.859	1404.24	"	"	77.09	69.22
" " "	"	"	½	34	182	24 75	30.90	.548	720.60	"	"	41 20	60.07
R. D. Wood & Co. (Geyelin)	Nov. 3		1	80	213.5	68 32	29.30	.896	1494.72	.040	14.35	81.89	83.43
Chase Turbine Co	Nov. 6 & 7	24″	1	42	355	59.64	29.80	.925	1506.84	.040	14 35	83.79	71 02
" " "	"	"	¾	37	360.5	53.35	29 62	.867	1423.68	"	"	78.74	67.75
" " "	"	"	¼	28	328	36.73	30.10	.746	1188.02	"	"	63 85	57.52

others, and acquitted itself in a very creditable manner under it. The table shows, too, that the volume used at the different fractional gate performances, as compared with that used at full gate, approaches quite nearly to the fraction of gate claimed by the exhibitor to be open at the time; which is quite rarely true of the other wheels.

Fig. 28 is a perspective view of Care's patent wheel, manufactured by the National Wheel Company, Bristol, Conn.; and it furnishes another example of the prominence given to the question of efficiency under partial gate, and the amount of study and research expended upon it. The method of reducing the flow of water to this wheel is perhaps the most original of any of them, is a more decided departure from the beaten paths, and is certainly ingenious and simple. The periphery of the case is divided into eight parts, four of these being virtually solid triangular blocks, the vertices of which adjoin the periphery of the wheel in such a position that one of the sides of the triangle is tangent to it. The other four octants are each divided into four chutes or adjutages for the admission of the water. Outside of the case are four gates in the form of octants of a cylinder of that diameter, joined together at the top and bottom, and operated to rotate upon the periphery of the case by the pinion and rack shown in the cut. With this construction, while the water is admitted at but four octants of the circumference at full gate, viz., while the gates cover the circular bases of the triangular blocks mentioned above, it meets the entire periphery of the wheel, and fills every bucket, the form of the chutes being nearly parallel. The partial gate adjustments may be only for ¾, ½ and ¼ gate, which divisions, however, are sufficient for all practical purposes, and when the gates are set for ¾, three of the chutes in each octant remain full open, and the fourth is entirely closed, and similarly, for ½ and ¼ gate, two and one chute respectively in each octant remain open; and when the gates are made to cover all four chutes in each octant the water is shut off. The object here has evidently been to avoid any reduction in volume in the veins of water impinging upon the buckets, and to reduce the power of the wheel by reducing the number of the veins. This would seem to be an admirable arrangement and should give excellent results with reduced supply of water. It is much to be regretted that the wheel sent to the Exhibition by this Company, giving as it did so high a percentage under full gate, was not in a condition to warrant the exhibitors in submitting it to partial gate tests. The wheel was so nicely fitted in the shop that it did not run freely, binding in the case, which would, of course, have detracted more from its efficiency under partial gate than under the full flow of the water. The inventors, however, claim to have entirely reliable records of partial gate tests made with it, which fully sustain their claims for its high efficiency under fractional admission of water.

Fig. 29 is the wheel manufactured by Goldie & McCulloch, of Galt, Ontario, Canada. It is a new wheel, and has not yet been placed upon the market; the manufacturers are just now completing some important improvements to their gate arrangement. The wheel itself, seen at the right of the figure, is a noteworthy piece of mechanism, and to its merits are due, probably, more than to anything else, the excellent results obtained from this instrument. These exhibitors, too, would seem to have been not entirely alive to their own best interests in failing to see that their wheel was run at the proper speed. A comparison of the different runs at full gate, and in equal measure with the fractional gate runs, it appears that at the commencement of their tests in each case the wheel was run at too high a speed, as at every reduction of speed the efficiency was increased, and the runs given in the table are all of them those which were had under the lowest velocity for the given gate. The exhibitors now think, and with good reason, as it would appear from the facts, that even the lowest speeds at which the wheel was run at every gate was too high to exhibit the maximum efficiency of which the wheel is capable. The lower part of the bucket in this wheel is curved in form very similarly to the Jonval wheel, and the upper part is a continuation which is very nearly perpendicular. This vertical continuation runs behind the center, at about a right angle with the center line of the interchutes. The gate is of the register kind, and is revolved upon the outside of the chutes by a segment and pinion, in the usual way. The wheel, chute ring, and gate ring are each cast in one piece, and bored and turned to fit accurately, reducing the leakage to a nominal amount, and making a very durable and reliable arrangement. The wheel tested was exactly such as is made for the market, and had no additional labor expended upon it for this occasion.

Fig. 30.

Fig. 30 is the Tyler Wheel, exhibited by the Putnam Machine Co., Fitchburg, Mass., but must not be confounded with the wheel which has been known in the past by that name, as it is entirely new, and embodies the results of a long series of experiments and much study on the part of its inventor, who has long been known as a worker in this field. The principal points in which this wheel has been latterly improved are: the form of the buckets, the manner in which the water is conducted to them, and the construction of the gate and apertures; the latter being such that the same tapering form is preserved at all fractions of gate. There are only six apertures used in any sized wheel, large or small. The table shows for this wheel, that while its efficiency under full gate reaches a high figure, that when using about one half the water—called in the table ½ gate—the efficiency was but about 10 per cent. less. It is very simple in construction, and the gate is always in equilibrium, so that it is adjusted as easily with the water upon it as without, and whether placed within or without the flume. The wheel and curb are both cast in one piece, and, in fact, there are but four main pieces in the completed machine. It appears to be very substantially made, and well proportioned as to strength of the different parts, and it certainly should be very durable.

This wheel labored under the disadvantage of having a larger shaft than any of the others, carrying the dynamometer down some 16 inches above the upper bearing, which certainly was not conducive to the most perfect working. It was found upon taking the wheel out of the flume that the effect of carrying the dynamometer drum so high above the upper bearing of the shaft was to set up a kind of vibration which resulted in loosening the shaft in the stuffing box, and causing the rim of the wheel to strike the curb.

It was expected by the exhibitor that a second test with a shorter shaft would be made, which latter he had prepared for the purpose; the test was not had, however, and the record stands, as shown in the table, for the best runs.

The accompanying table would have been made to include a greater number of runs for each wheel, but for the great length to which it would extend this article; that which is, however, just alike to all has been done, and the best result gotten at each gate only given. Any one, however, desiring the full record can doubtless obtain it from the authorities, who now have the official report in print.—J. T. H.

NEW COMPRESSED AIR LOCOMOTIVE.

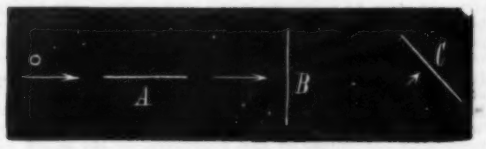
Some preliminary experiments are being made in the Royal Arsenal with an engine designed by Major Beaumont, R.E. At present nothing is perfected. The engine moves about slowly on the line, but little has been done beyond the proof of the feasibility of its action. The question is an important one, so that it is worthy of attention even at this stage of the experiment. As traffic increases, especially in our metropolitan districts, horse power becomes inconvenient and inadequate to meet our requirements. Tramways doubtless gives it increased scope, but sooner or later engine power of some form seems likely to come in much more extensively than at present. Many believe that steam locomotion on railways cannot meet our requirements, and some power will be found that is suitable for working on roads generally. Air engines have long been looked to as likely to come in in some form. In the abstract there appear to be certain advantages possessed by air as a motive power over steam. The noise, the smoke, and dirt of ordinary steam engines make them unsuitable for running on public roads. It is well, then, to come at once to the general principle of the design before us. In a steam locomotive we have the elements for manufacturing our motive power, and we perform the process of manufacturing it as we go. We have our coals and our water, and we have our furnace and our boiler, with tubes for evaporation at the extraordinary rate necessary to produce the motive power we require. To run for long distances all this is necessary. For the short stages that may be sufficient for the traffic on public roads, Major Beaumont suggests that it is preferable to have a vessel charged with the motive power—namely, compressed air in sufficient quantity to work the cylinders of a small locomotive engine at a low pressure. Major Beaumont wishes to work up to 1,000 lb. per square inch. At present nothing like this has been done, but locomotion has been obtained with a pressure of about 200 lb. The engine has been handed over to the Royal Laboratory department by Mr. Hay, the head of the machinery deparment, and has been charged with compressed air, very much as if it were a gigantic Whitehead fish torpedo, by the pumping engine used for that purpose. The air is contained in iron cylinders or tubes in five rows, those of each row being connected together, and being practically one air vessel. Each row or vessel, then, can be made to work in succession on the cylinders of the engine, which happen also to be five in number for the full pressure, but for the lower pressures at present four only are used. The smallest of these works on to the next, and so on in succession on the usual compound principle, the last and largest one working at a very small pressure against the atmosphere. The engine is intended to carry a sufficient supply of air to run for perhaps ten miles, when it would be recharged by a stationary pumping engine. The pressure of each vessel must become less and less as the air is drawn off; but the next vessel can be employed to assist the working one when it becomes weak; so that until the end of the run there ought to be all the power that is required. At present it is quite premature to speak of results. In the Royal Laboratory the pumping engine has to work for about seven hours to supply the small locomotive for a run of half an hour. This, no doubt, is due in great measure to the special circumstances of the case. It does appear probable, however, that the waste of power in pumping and charging the engines will constitute an enormous and costly difficulty when the problem takes a practical shape. The carriage of a great quantity of air under compression, even though it be divided into several vessels, is again an ugly feature in the design. Safety certainly would be on the side of carrying our raw material and manufacturing our motive power, rather than carrying the entire store of it for the journey in what is liable to be so dangerous a form.—*The Engineer.*

The Municipal Council of Paris have lately inspected the London Underground Railways, with a view to the introduction in Paris of a similar system for rapid transit. All the principal railway stations and business centers will be connected by the new railway, which will pass under the sewers, 23 feet below the pavements, have a length of seventeen miles, and cost about thirty millions of dollars.

WHY AN ICE YACHT SAILS FASTER THAN THE WIND.

THERE have been numerous explanations written, some involving mathematical and mechanical calculations of an advanced order, regarding the paradoxical behavior of the ice yacht in sailing faster than the wind which impels it. The problem, we think, can be satisfactorily solved, without resorting to theoretical mechanics or Greek letter formulæ, and need involve only the statement of a few simple and rudimentary physical laws which even those not versed in scientific reasoning may clearly comprehend.

It is first necessary to understand why a vessel can be made to travel apparently against the wind—that is, how a ship by sailing at certain angles to the wind can eventually reach a point dead to windward of her starting place. To this end we shall consider first simply the sail without regard to the body of the vessel—and the direction of the wind.



Let A be the sail and the wind be indicated by the arrow. Then, as the sail is edgewise to the wind, it is clear that the latter will exercise no effect upon it except to shake it—we place an O over the arrow to indicate this. On the other hand, it is evident that with the sail perpendicular to the wind as at B, the wind will then act upon its entire area and have a maximum effect. Then necessarily, if we place the sail slanting to the wind as at C, it follows that the wind must have an effect which will be greater as the angle of C approaches the perpendicular B, and less as it nears the horizontal A. If we let the arrow at B represent by its length the strongest action of the wind on the sail, then we may represent its lessened action on C by a smaller arrow. The reader will, therefore, bear in mind that no matter what angle we place our sail C to the wind—the latter will always in some degree—larger or smaller arrow—act effectually against it.

Now let the sail be attached to a car which we will suppose slides on runners in grooves without friction. It can, therefore, only move forward and back, and is prevented from moving sideways. In D E and F, we have added our pair of runners, the dotted lines show direction of the grooves; clearly the wind at D acting only on the edge of the sail will, as already proved, have no effect on the car. At E, the sail being perpendicular, the wind will at once have its maximum effect, and the car will move ahead. At F, however, the wind has a certain reduced effect on the sail, which in turn acts on the car. Now if the pull of the sail were directly across the grooves, then it is clear all the force would be expended against their sides and the car would stand still.

But in F the sail pulls, diagonally across, as shown by the little arrow; hence, while part of its pull is wasted against the grooves, another part tends to move the car ahead; that is, diagonally up the page. Thus it will be seen that, although we have wasted part of our breeze by setting the sail at an angle to it, and of the available portion thus left we have also wasted a fraction because of the disadvantageous angle under which it is compelled to pull or push the car, we still have a remainder available for moving our car ahead in a course which tends to carry it directly to windward.

It should be clearly understood that the wind we have wasted does not act against our available remainder, and that the only retarding force is friction (hitherto neglected, but which we shall soon consider) between car and grooves. Our available remainder is, therefore, a constant force, and a constant force acting upon a body produces an accelerated motion. This is plainly demonstrated by the action of gravity upon a falling body; or a steamboat, for example, its engine working at regular velocity, starts off slow at first, then its speed gradually increases up to a certain point, when it remains unchanged as long as the moving force is unchanged. But the steamboat in moving has to push aside a certain amount of water in a second, and the faster the boat goes the more water has to be moved. If the speed doubles, twice as many particles of water must be pushed aside, and each particle must be moved in half the time; so that in order to double the speed of the vessel the power must be quadrupled, and in general terms the resistance increases as the square of the velocity. Without such resistance it must be clear that the speed would go on increasing—the moving force remaining the same—forever, and the rate of increase would depend on the magnitude of the moving force. But it is certain that no matter whether that force were large or small, so long as it existed, there would be a constant acceleration augmenting either rapidly or slowly. This condition of affairs is exactly that of our frictionless car at F. Here there is the available remainder of our wind, a constant force, with (as supposed) no friction to retard it. Hence that car would not only virtually reach a point to windward, but would eventually pursue its course with infinite velocity.

Now we can abandon our frictionless car, and consider the ice boat. The latter is like a skate, which can be moved best ahead when in use, and with difficulty sidewise. Hence we may consider that the ice boat has no leeway, and to all intents, runs in grooves of its own cutting. The conditions governing our imaginary case, F, are all complied with except absence of friction, and the small wind pressure on surfaces turned disadvantageously to the direction of motion. These last are so small an area as to be practically inconsiderable. There is then the friction between iron runners and ice, which is likewise necessarily small. It depends of course on the weight of the vessel; but what the proportion is, in the case of ice and iron, is not definitely determined. It is certainly less than between beech and oak wood lubricated with tallow, which is only .05 the weight, because between ice and iron are the most favorable conditions for conducting off the heat generated and practically perfect lubrication. Now, for friction to increase with velocity, depends on the incidental causes of resistance of the fluid in which the object moves, and generation of heat, both of which are here reduced to probably the very lowest point. Hence, it appears that the frictional resistance remains practically stationary; and this while, as already demonstrated, the velocity is constantly increasing. Hence, as a necessary consequence, the vessel will continually augment in speed, and will reach a velocity faster than that of the wind, in a period the less, as the accelerating force of the wind is greater. And further, in the absence of accidental causes of retardation dependent upon build, rig, set of sail, area of resistance to onward movement, etc., and with unlimited ice room, there is no reason why an ice boat should not attain a speed immensely greater than that ever reached by means of locomotion now in existence.

THE ICE YACHT ICICLE.

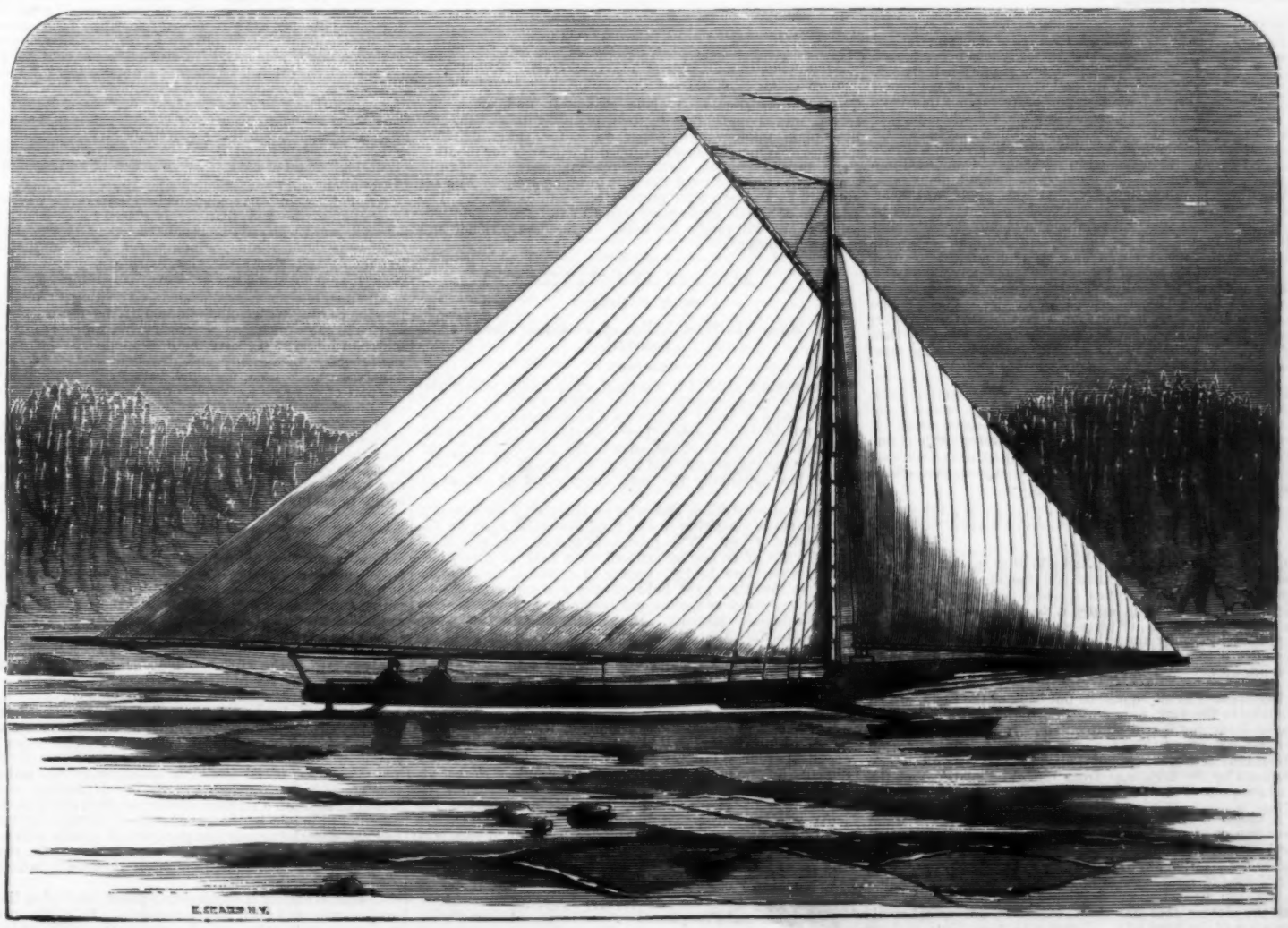
IN our SUPPLEMENT No. 1 we gave the working drawings and dimensions for ice boats, as used on the Hudson River, together with details as to their management.

The headquarters of the sport in this country is the Hudson River, notably at Poughkeepsie, while the Canadians also indulge in it extensively, especially in Toronto Bay, where a fair field of ice is often afforded. At Poughkeepsie there is a regularly organized club for ice-yachting, and the picture we present, from the *Spirit of the Times*, is of the Icicle, the craft belonging to the commodore of this club, Mr. J. A. Roosevelt. She is decidedly the largest of the yachts composing the Poughkeepsie fleet. As will be seen by the engraving, she is sloop-rigged, and her dimensions are: extreme length, sixty-eight feet ten inches; length of frame, twenty-nine feet two inches; width between runners, twenty-five feet seven inches; area of sails, one thousand and seventy square feet. This is an immense amount of canvas for so slight a craft to carry.

The speed attained by these boats, when the ice is smooth and the wind just right, is wonderful. The most curious fact is that, under the conditions just mentioned, they sail much faster than the wind. A wind moving with a velocity of fifteen miles an hour will drive the ice boat sixty miles an hour.

Among the most prominent objects exhibited at the Centennial was the magnificent ice yacht, "Whiff," owned by Commodore Irving Grinnell, of New Hamburgh, N.Y. We have in preparation the full working drawings of this craft, which, with full particulars, we shall give in future numbers of the SUPPLEMENT. Speaking of ice boat sailing, Commodore Grinnell says:

"An ice yacht sails faster than the wind, because she invariably sails at some angle to it. It takes but little wind to overcome the slight resistance from friction, and to give the yacht a certain headway; after which each additional impulse of the wind, striking the yacht obliquely, serves to rapidly augment the momentum, till a point is reached where any further increase of the latter is counterbalanced by the increase of friction. In other words, in the absence of much friction, there is a desire on the part of the yacht, after receiving an impulse from the wind, to keep going ahead at the speed already acquired, thus permitting the next impulse derived from the wind to be devoted almost wholly to an increase of speed; and in this manner it will be understood that a constant, rapid succession of such driving thrusts of the wind against the sail must eventually cause much greater accumulation of speed in the ice yacht than that actually possessed by the wind itself. If the yacht sailed directly before the wind, she would be entirely at the mercy of the wind, and, like a balloon, could never sail faster than the wind was blowing."



THE ICE YACHT ICICLE. COMMODORE J. A ROOSEVELT.

[The Practical Photographer.]

PHOTOGRAPHIC NOTES.

Photo-Intensifying.—We have made some experiments with a new intensifier, which we can recommend as something very useful in the hands of those of our readers who are copying line engravings, etc. The process was invented by Messrs. Eder & Toth, of Vienna, and published in the *Photographic Correspondent* by its editor, Dr. Hornig, at Vienna:

6 parts red prussiate of potash,
4 parts of nitrate of lead,
100 parts of water.

After fixing the negative, wash it well and apply this solution; after awhile wash again, and pour over it a diluted solution of sulphuret of ammonia. The intensity obtained by this intensification is three times as great as can be obtained by any other method.

Photo-Transparencies.—Instead of backing them with ground glass, simply add a few drops of shellac varnish to ordinary collodion, iodized or not; the more varnish you will add the denser will be the ground glass effect, and varnish the transparencies with this solution, which is finer than ground glass.

Copying Photos at Night.—I have been in the habit of making copies of photographs or other pictures at night, when busily engaged during the day. This is how I do it: Place the camera and picture to be copied in the proper position, and, when ready to expose, hold a kerosene lamp near the picture in such a way that the light will fall on the picture in the same direction that it fell on the subject when the original picture was taken. Now, place behind the lamp a silvered glass reflector, so as to concentrate the light on the card, and while exposing keep the reflector in motion, so that the picture will be equally lighted all over. Expose three or four times longer than in daylight, and use the developer double strength, or vary the time to suit each case. By this means I have made as good copies at night as in daylight. The lamp should have an Argand burner, and the reflector should be a glass one, such as is used on bracket lamps. Thos. C. Harris.

Side-Lights.—Photographers are very often troubled with too much light, especially side-light caused by the sun shining in, or reflected light from other buildings, or when the light is on the ground floor. To obviate this, you will find blue paper or muslin curtains keep out reflected light that might otherwise shine in through the side light without obstructing the working quality of the direct light. The easiest and best way to work them, is to make them in four parts square, to cover your side-light so that you can pull them back or forward either way when needed. Have rings sewed on about six inches apart, and have your window divided off the same in four parts, by four wires fastened with screw eyes, and let your curtains run on them. Leave the curtains a little full, and see that they lap over each other about six inches, when closed, which prevents rays of light striking through.

Good Mucilage or Gum Solution.—Prepare it as follows: Get some of the best white gum arabic, dissolve it in pure water, keeping it well covered to prevent the dust getting in. Make it rather thicker than cream, and add about a tablespoonful of spirits, and a small lump of loaf sugar, about the size of a hazel nut, to two ounces of the gum solution. The spirit helps dissolve the gum, and the sugar prevents it cracking.

Copying Pictures.—Copy daguerreotypes in reflected sunlight—that is to say, through the rays of the sun reflected from a small mirror on to the picture while it is being copied—dust it off before copying, with a fine camel's hair duster, crosswise of the figure, not up and down, or you may spoil it. Never varnish old ambrotypes or ferrotypes that have not been varnished, or, ten chances to one, the whole picture will disappear; but you can revarnish those that have been once varnished, dented, or soiled, and it will greatly improve them. They should be copied in the shade. Copy card pictures or photographs of any kind from behind plate glass, and they will be much smoother. Another plan: wet them, and copy them the same way for enlargement; try and be convinced. In copying oil paintings, a cloudy day is preferable; by no means copy in the rays of sunlight. They require three to four times as long as photographs to copy. Pictures copied the size of the original generally take twice as long as from life, the light being of the same strength; enlargements much longer, according to size. Focus copies without a diaphragm, but put it in or regulate before copying the picture. A side light is much better to copy by than sky-light. Your picture and camera should be on the same attachment board.

Photo-Burnishing.—Rub over your prints and mounts, before burnishing them, the following solution, which is the best we know or have heard of. It is perfection itself. It keeps out moisture from the prints, and preserves them and gives a brilliant finish, far superior to any soap or soap solution, which absorbs moisture and soon injures the picture. Take as follows:

White wax	120 gr.
Ether	2 oz.
Alcohol	16 oz.

Cut or scrape the wax fine, and add it to the ether; shake, and it will soon dissolve; then add the alcohol, shake well again to mix; when it settles, a white sediment will fall to the bottom. Before you apply it to the picture, shake up each time. A sponge, or piece of canton flannel with short nap, is best to apply the solution to the picture with. Let them dry before burnishing—not too dry; it will take but a few minutes.

Blotting Paper should be put back of the plate, after it is coated in the dark room, to absorb the waste and superfluous silver that is still on the plate. It is astonishing how few galleries adopt this plan of saving waste silver solution. Thousands and thousands of dollars are lost yearly to photographers by the drippings from the glass plates alone that are taken out of the negative bath.

A Good Working Developer.—Half a gallon of water, four ounces of protosulphate of iron, four ounces of acetic acid No. 8, two ounces of alcohol. This solution is good either for negatives or ferrotypes. For children, have a bottle of iron of double the strength of the above, or for short exposures; also warm the developer and it will help to bring out the picture that has short exposure, but would spoil a negative of the right time. Never rock your plate in developing if you want fine detail.

PRINTS FROM FUNGI.

M. Poitevin has often remarked that certain fungi or mushrooms (*agaries*) after they had arrived at a certain stage of maturity, when placed upon a plane surface of marble or glass, left behind them, after a few hours, a very clear image of their leaves, etc., in half tones. This image was formed by the colored dust between the leaves which falls upon the surface on which the fungi had been lying. M. Poitevin tried to reproduce the same effect, but under more favorable conditions. He experimented with sheets of glass, or paper stretched very evenly over glass, and having placed the fungus upon this surface, covered it up with a glass shade to prevent the surrounding air having an effect upon the fall of the dust. After an interval of five or six hours, he obtained a very clear impression of the leaflets. The image was not in any way stable, for the dust did not adhere to the paper, and was disturbed on the slightest friction. At the same time, he succeeded in fixing the image by employing a varnish made by dissolving a gum resin in alcohol or essence, a method which he afterwards abandoned for a better plan of operating. At present he makes use of a sheet of paper prepared with gelatine on one side only; he puts this sheet upon a plate of glass, gelatine face uppermost, and having moistened it with a brush, spreads the sheet flat with the same means. The film of gelatine is in this way moistened, and the superfluous moisture having been removed, the mushroom or fungus is put upon it, the leaves downwards. If the fungus is light and small there is no necessity for suspending it, but otherwise it must be removed at some distance from the sheet, as the leaves will get folded and the image will not then be distinct. M. Poitevin suspends his fungi by means of little supports made of thin metal and thread, from the centre of which the mushroom hangs. The whole is covered up by a glass shade, and the formation of the image allowed to proceed for five or six hours according to the season or quantity of pollen contained in the fungus. At the end of this time the shade is removed, and the fungus carefully lifted off the paper, and the result is upon the gelatined paper, a most perfect image which is fixed as soon as ever the paper is quite dry. The same fungus will furnish successively three or four impressions. Some of the fungi are brown, violet, yellow, etc., and they yield prints of these colors. In the case of the lighter colors, such as yellow and white, they are reproduced upon gelatine tinted of a sombre color.

M. Poitevin has illustrated this communication of his by a print of the edible mushroom, which has at first rose colored leaves that afterwards become brown after some days. The color seems to be quite permanent so long as the impression is kept from the damp. M. Poitevin thinks that the process might be turned into a method of photographic printing, and in this wise:—Upon a metallic fabric of very fine silken stuff is produced a cliché, in which the parts corresponding to the whites will be impermeable to the dust or coloring matter, while the black and half-tones allow the powder to pass in direct proportion to the intensity of the tones of the design to be reproduced. M. Poitevin has promised to make some experiments in this direction, and to communicate to us the result.

BLUE PRINTS ON PAPER, WOOD, ETC.

By T. C. Roche.

The following method gives fine blue prints on paper, wood, canvas, etc., and only requires washing to fix properly:

First Solution.

Red prussiate of potash	120 grains
Water	2 ounces.

Second Solution.

Ammonia-citrate of iron	2 ounces.
Water	140 grains.

The solutions should be made separately, and, when dissolved, mixed and filtered; then pour it into a dish, and float plain photographic paper on it for three or four minutes. When the paper is dried it will keep for months. Print in the sun for eight or ten minutes; then simply wash the paper under the tap with running water. The result will be a strong blue picture on a white ground. The addition of a little gum-arabic water to the above solution, when made, will render the color of the picture richer and the whites purer.

ALBUMEN AND GELATIN.

By A. P. Clark.

[Read before the West Riding of Yorkshire Photographic Society.]

ALBUMEN.

This name is applied to a certain organic body which constitutes the characteristic portion of the white of egg, and of the serum of blood, and forms a constituent both of the animal fluids and solids. There is also a vegetable albumen found in certain plants, such as the potato, carrot, turnip, cabbage, asparagus, and the green stem of the pea, etc., which has apparently the same composition as animal albumen.

The most remarkable character of albumen is the property it possesses of changing from a fluid to a solid state on the application of heat. This process is termed "coagulation." If the white of an egg be exposed to a heat of about 140° Fahr., white fibres begin to appear in it; and if the heat be raised to 160° Fahr., the fluid substance is converted into a solid mass, which is opaline and insoluble, and is possessed of considerable elasticity. If the heat be still further increased to 212° Fahr., it dries, shrinks, and assumes the appearance of horn. It can, however, be dried at a temperature of 140° Fahr. without being rendered insoluble, and it is in this form that it is usually met with in commerce. It is inodorous and tasteless, and is insoluble in alcohol and ether.

The chemical composition of albumen has not been ascertained with certainty, as it is so readily split up by different chemical agencies into many other substances for which it is difficult to obtain an exact chemical formula. Recent analyses, however, by G. S. Johnson, of some remarkable compounds of albumen with the acids confirm the formula originally proposed by Lieberkühn, namely, $C_{72}H_{112}N_{18}O_{22}$. The percentage composition is in round numbers:

Carbon	55 per cent.
Hydrogen	7 "
Nitrogen	16 "
Oxygen	21 "
Sulphur and Phosphorus	1 "
	100

Albumen, whether obtained from eggs, blood, or plants, has the same constituents.

White of egg consists of about twelve per cent. of albumen, eighty-six per cent. of water, and small quantities of soluble salts. It is alkaline from the presence of a little soda. Raw white of egg has no smell of sulphuretted hydrogen, and does not blacken silver; but after boiling both these qualities are manifest, showing that it suffers some decomposition during coagulation.

In proportion as albumen is diluted with water it requires a higher temperature to coagulate it; but water with only the 8th part of its weight of albumen dissolved in it is rendered opaque by boiling. After coagulation it is no longer soluble in water unless heated with it under pressure, but it dissolves in caustic alkali. The only chemical change that can be traced is the loss of alkali and soluble salts, which are removed by the hot water.

Albumen is coagulated also by alcohol and by all the stronger acids, as sulphuric, nitric, and hydrochloric acids; but not by acetic acid, as that dissolves it. It is also coagulated by the metallic salts, such as chloride of tin, chloride of gold, and acetate of lead; and so delicate a test of the presence of albumen is bichloride of mercury that, if a single drop of a saturated solution of that salt be let fall into water containing the two thousandth part of albumen, it will occasion a milkiness in the water, and produce a curdy precipitate. Albumen is also coagulated by the action of voltaic electricity

The yolk of egg contains a modification of albumen called "vitelline," and owes its yellow color to a yellow oil, which may be extracted by ether, and contains phosphoric acid.

It is a well-known fact that certain industries consume a very large quantity of albumen in some shape or other. Sugar refiners, tanners, and glove-leather makers employ albumen in a more or less pure state—in some instances the yolk of egg only; but the calico printers are the largest consumers, it being used by them as a mordant for dyeing cotton goods with aniline colors. This consumption is steadily on the increase. A short time ago it was stated in a scientific paper that the printing works of Alsace alone consumed annually more than 150,000 kilogrammes of dried albumen, represented rather more than thirty-seven millions of eggs, or the production of 250,000 hens. Add to this the consumption of the printing works in the other parts of France and of other countries, and there is very little doubt that annually some one hundred and fifty millions of eggs are used for that purpose alone.

Two kinds of dried albumen from blood are known in commerce, namely, the natural albumen without gloss, and patent or glossy albumen. The white of egg can also be purchased in the form of a dry powder, and it has been proved to be perfectly soluble. Dr. J. Schnauss has already borne testimony to its value in the preparation of dry plates, and, being in the form of a powder, it is very economical, as no more solution need be prepared than is required.

Albumen has never been obtained perfectly free from saline matters, particularly the alkaline and earthy phosphates; and for photographic purposes it is very probable that the sulphur present in albumen is very detrimental to silver prints. Experiments have been made from time to time by chemists, with a view to the separation of the sulphur from albumen, and whether, if it were removed, the albumen would still retain its properties, is yet an open question. That there is reason to believe that some process will yet be discovered, may be inferred from the fact that M. Schützenberger has ascertained that when pure albumen is coagulated by heat, it always leaves a small amount of soluble residue, amounting to from five per cent. to seven per cent. of the original albumen. He states that this residue is of a clear yellow color, has a bitter taste, and, what is of more importance to photographers, contains sulphur. Although the albumen, after being coagulated, is of no use to the photographer, still it is a step in the right direction, and perhaps we may ultimately be able to prepare albumenized paper, etc., without having the presence of this deleterious substance.

The defects in some albumenized papers may also be attributed to the fact that highly glazed paper is much in demand, and it can only be produced from albumen that has undergone fermentation. Such paper is often unequally sensitized, and shows circular markings, tear-drops, and blisters, as pointed out by Mr. Bovey some time ago.

Albumen is often recommended as a coating to plates before the coating with collodion, and is, no doubt, of great service in the working of dry plates, but probably a fruitful source of injury to the silver bath, if adopted in the ordinary wet process. Clean plates and good collodion render its use unnecessary. If used, it should be a weak solution, about one part of albumen to twenty or twenty-five parts of water, and filtered before use.

In conclusion, I would say that, although dry albumen from a good maker can be relied upon, still there is no doubt that the cheaper qualities are adulterated with such substances as gum, dextrin, or British gum, or starch, and sometimes, without being adulterated, may be of inferior quality, owing to having been dried at too high a temperature.

GELATIN.

In reference to gelatin, I can say very little; it is prepared from animal substances only. That quality generally used by joiners as glue is prepared from the refuse of the tanyards, consisting principally of scraps and parings from the raw hides, though it can be, and probably is, prepared in some places from bones. Isinglass is a very pure variety of gelatin, prepared from the air-bladders of fishes, more particularly that of the sturgeon. The composition of gelatin is usually stated by the following formula: $C_{11}H_{17}N_{13}O_{14}$, and also a trace of phosphate of lime and magnesia.

The characteristic properties of gelatin are the tendency of its solution to gelatinize on cooling, and the formation of an insoluble compound with tannic acid and some other substance—for instance, chrome alum by the action of light. The formation of an insoluble substance by the action of tannic acid is the foundation of the art of tanning, and the action of light on a mixture of chrome alum and gelatin the essential principle in the production of carbon prints. A solution containing only one per cent. of gelatin will set on cooling, and this property renders it valuable in the making of jellies, size, and glue, though, if repeatedly boiled and cooled, it loses this property.

Gelatin is largely used for sizing paper, clarifying liquids, such as wine and beer, and as a cement. It is also used in various ways in the art of photography, with which, no doubt, many present will be more familiar than I am.

WASH-BLUE AND ITS ANALYSIS.

By H. D. DEBRUNNER.

THE different pigments sold as "wash-blue" chiefly consist of Prussian blue, or ferric ferrocyanide ($FeCy_{1.5}Fe_4+18H_2O$; some of them, however, are prepared by immersing starch in cold solutions of indigo or anilin blue, by which process the pigment is absorbed. The latter kind is not very often met with; indeed, I think there is hardly any in our present market. The former kind of blue, however, on which I made a series of experiments, is found in almost every house, under varying names, often as a dry powder, put up in "patent boxes," sometimes, also, in solution.

Soluble Berlin blue, as the term is used in science, is not found in the market. I am referring to the blue precipitate formed on the addition of ferric sulphate or chloride to an excess of potassic ferrocyanide. The blue precipitate thus formed contains potassium, and is soluble in distilled water as soon as freed from adhering mother-liquor. Its formation is illustrated by the following equation:

$$2(K_4FeCy_6)+Fe_2Cl_6 = 6KCl + 2(FeCy_4K)Fe_3$$

potass. ferrocyd. + ferric chld. = potass. chld. + sol. blue.

It is precipitated from its solution by shaking it with such indifferent pulverized substances as baric sulphate, and the same effect is produced by hard water and salt solutions, which qualities render it unfit for wash-blue.

The only allied compound which finds application as wash-blue is insoluble in water, and is obtained by the addition of a solution of potassic ferrocyanide, $K_4FeCy_6+3H_2O$, to an equal quantity of copperas, $FeSO_4+7H_2O$, also dissolved, and subsequent treatment of the white precipitate ($K_2Fe_2C_{12}N_{12}$) with a mixture of nitric and sulphuric acids. The product of this process is insoluble in water; it will, however, readily dissolve in solutions of ammonic tartrate, oxalic acid and potassic ferrocyanide. Only the latter two solvents are of practical importance. Oxalic acid should be used in proportion of about ½ of the weight of the dry blue in order to dissolve it entirely. Since oxalic acid is a poison, it is doubtless preferable to substitute it by an equal amount of potassic ferrocyanide, thus obtaining a perfectly harmless product. For the manufacture of blue ink I should prefer the latter solvent already on account of its not corroding steel pens. The addition of the potassic ferrocyanide is done best when the previously formed and oxidized precipitate is sufficiently washed and of the consistency of a thick pulp (60 per cent. water). The mixture then is repeatedly passed through a mill, dried at about 120° F., and ground, when it is ready for sale. 100 lbs. of potassic ferrocyanide thus yield 80 lbs. of dry blue (almost exactly the theoretical amount), which require about 12 lbs. of $K_4FeCy_6 3H_2O$ to become soluble.

The pigment thus obtained forms a light, dark-blue powder, perfectly soluble in water; in lumps it possesses a handsome bronze tint. The color of the solution is a beautiful blue-violet, similar to the shade obtained by the action of ammoniacal vapors on the pure blue pigment. Sometimes, particularly if precipitated from very dilute "liquors," its solution shows flourescence. It cannot be denied that the cost of this blue is higher than that of the one rendered soluble by oxalic acid. The "patent" boxes, however, it is sold in contain such homœopathic quantities (average 60 grains, sold at ten cents) that the cost of package and label far surpasses that of the contents, still leaving a fair profit to the wholesale manufacturer.

The greater number of the "wash-blues" in the market contain oxalic acid, the detection of which is by no means so easy a matter as might be imagined. It is evident that on addition of calcic acetate not only calcic oxalate will precipitate, but also the Berlin blue, which thus becomes deprived of its solvent. The non-transparency of the solution (except on excessive dilution) neither facilitates a direct reaction. The method which I would propose, and which has given very satisfactory results, as well for the qualitative detection as for the estimation of oxalic acid, in this case is as follows:

About 10 grains of the blue to be tested are heated with caustic soda. The pigment thus becomes converted into sodic ferrocyanide and hydrated ferric oxide, while the oxalic acid will form sodic oxalate. The iron is filtered off and the filtrate acidified with dilute acetic acid. If oxalic acid is present, calcic oxalate at once will precipitate on addition of calcic acetate. As all the circumstances for the formation of ferric or a basic oxalate are present, it is advisable to dissolve the ferric precipitate in a few drops of hydrochloric acid; add sodic acetate and acetic acid to the *cold* solution, which, although assuming a red color, will not form a precipitate of basic acetate of iron except on boiling. On addition of calcic acetate, the oxalic acid can be recognized by the precipitation of calcic oxalate, and it may be estimated in the usual manner if a quantitative determination should be desired. Although I have never found oxalic acid in this ferric precipitate, I would recommend not to omit testing for it.

As to the detection of potassic ferrocyanide in wash-blue, I have seen the following test applied, viz.: A few drops of the concentrated blue solution are dropped on a piece of filtering paper and allowed to spread. Owing to the capillarity around the blue spot, a colorless wet zone will form, which, although being hardly of the breadth of $\frac{1}{16}$th of an inch, will allow the detection of potassic ferrocyanide on adding to it a drop of a dilute solution of ferric chloride by means of a thin glass rod (formation of Berlin blue).

For information I should recommend the following tests:

If potassic ferrocyanide is contained in a wash-blue, the aqueous extract of its residue on ignition will contain potassic cyanide (silver reaction AgCy; boiling with a drop of ammonic sulphide and addition of a drop of ferric chloride Fe_2Cl_6—red color). As it takes a very low heat to decompose Berlin blue, said aqueous extract sometimes contains undecomposed potassic ferrocyanide. Test with ferric chloride.

Pure Berlin blue, ferric ferrocyanide $(FeCy_6)Fe_4+18H_2O$, loses, at 212° F., 7·22 per cent. of water, a fact the manufacturers are well aware of, and therefore never allow the temperature of the "blue drying room" to exceed 100° to 120° F.

On ignition, depending on the intensity of heat, varying mixtures of ferric and magnetic oxide remain as residue. The loss on ignition, therefore, does not allow any conclusions on the quantity of blue present (for instance, in a mineral color), and an estimation of the ferric oxide, either by titration or weight-analysis will always be necessary. It is evident that this method would become incorrect if applied in the quantitative analysis of a blue rendered soluble by potassic ferrocyanide; it, however, can be successfully followed in the estimation of "oxalic acid blues." Wash-blue is hardly ever adulterated.

In order to ascertain the quantitative relation between the ferric oxide and the total quantity of blue, I prepared a pure sample by the same process as done on a large scale, and dried it slowly at 80° F. It corresponded to the formula $2[(FeC_6N_6)_4Fe+18H_2O] = 2368$, which will yield $7Fe_2O_3 = 1120$. 100 blue correspond to 47·290 per cent. oxide of iron.

1·00 gram of this pure ferrocyanide of iron lost on ignition 0·6058 = 60·58 per cent. of its weight. Actual residue = 0·3932 = 39·42 per cent. This residue then was dissolved, the Fe reprecipitated as $Fe_2O_3,3H_2O$, and finally weighed as Fe_2O_3 = 0·4750 = 47·50 per cent., nearly the theoretical amount.

From these data the quantity of pure blue can be calculated. I have, however, found that the pure "commercial blues" dried at a somewhat higher temperature, contain less than 18 H_2O, yielding 49·75 to 50 per cent. of Fe_2O_3, and consider it "practically correct" to multiply the quantity of Fe_2O_3 found, by two, in order to find the quantity of "commercial blue" present.

The numerous other blue pigments of this series, as, for instance, *Turnbull's blue* (ferrous ferri-cyanide $(Fe_2C_{12}N_{12})Fe_3$), *chromate blue*, so called from potassic bichromate and sulphuric acid forming the oxidizing agents of the previous white precipitate, $K_2Fe_2C_{12}N_{12}$; *steel blue*, the product obtained on treatment of said white precipitate with hydrochloric acid, etc., are never used as wash-blue, and therefore out of the range of consideration. In this connection I desire to express my thanks to Mr. John F. Grosskaus, who kindly assisted me in these investigations.—*American Journal of Pharmacy.*

A NEW DEVELOPER FOR DRY PLATES—HYDROSULPHITE OF SODA.

THE chief advantages of this developer are: 1. Shortening of exposure. 2. Freedom from objectionable smell of the alkaline developer, with better keeping qualities. 3. Freedom from fog during a prolonged development, giving thus a very great latitude in the time of exposure.

If bisulphite of soda ($NaO\ HO2\ SO_2$) be placed in contact with metallic zinc, a new substance is generated, viz., hydrosulphite of soda, with great reducing properties, which has been made use of by its discoverer, Dr. Schützenberger, in the dyeing trade, for the transformation of blue indigo into white indigo, which is soluble in an alkali. I will not enter into the theory of the preparation and uses of this substance, but only state its use in photography.

Prepare (A) a solution of forty per cent. of bisulphite of soda;
(B) a solution of twenty per cent. of pyrogallic acid (the first in water, the second in alcohol);
(C) a four-ounce bottle containing granulated zinc.

When wanted, pour solution A into the bottle C, the liquid filling up the interstices of the granulated zinc. Twenty minutes afterwards the reaction is complete. This solution keeps twenty-four hours only, for the absorption of the atmospheric oxygen gives an inverse reaction. The plate is wetted with water. Then put into a dish containing

Water	50 parts.
Solution of hydrosulphite of soda	50 "
Pyrogallic acid solution	4 "

In this the plate remains till completely finished with full printing density and every detail well out.

The time required for the development ranges from fifteen to seventy minutes. The exposure is considerably shorter than with the ordinary alkaline developer, but not quite so short as with Wortley's strong alkaline developer.

As soon as the hydrosulphite is mixed with pyrogallic acid the solution assumes a rosy tinge, but does not darken for at least eight hours, retaining all its developing properties, and this without fogging the shadows of the negative; so that detail may be "coaxed" out of an under-exposed negative without fear of a black veil covering the whole plate.

Collodion as well as gelatine dry plates may be developed by the hydrosulphite solution.

L. O. SAMMANN, C.E.

GENERAL METHOD OF ANALYSIS FOR THE TISSUES OF VEGETABLES.

By M. E. FREMY.

THE study of *organic substances*, so successfully pursued at present by a great number of chemists, should not cause us to overlook that of *organized bodies*, which are overlooked in these days, and which, nevertheless, are of great interest as revealing the compounds which are indispensable to the performance of the vital functions. The proximate analysis of vegetable tissues presents a difficulty which all chemists will understand, its objects being to determine the composition of a structure formed of insoluble elements in neutral solvents. The principal tissues of plants, after exhaustion by neutral solvents, are formed by the organic association of the following bodies: Cellulosic substances (cellulose, meta-cellulose, para-cellulose), vasculose, cutose, pectose, pectate of lime, nitrogenous compounds, and various mineral matters. Dilute cold hydrochloric acid decomposes the pectate of lime and sets at liberty the pectic acid, which is then easily determined by means of alkalies. Dilute boiling hydrochloric acid transforms pectose into pectin, which is precipitated by means of alcohol. Ammoniacal cupric reagent dissolves the cellulose. Boiling hydrochloric acid renders para-cellulose soluble in the ammoniacal cupric reagent. Bihydrated sulphuric acid dissolves the cellulosic substances. Dilute and boiling potassa dissolves cutose. Potassa under pressure effects the solution of vasculose. Dilute nitric acid renders vasculose soluble in alkaline solution.—*Comptes Rendus.*

OENOKRINE.

THIS is the name of a test paper sold in Paris for the purpose of detecting the fraudulent coloration of wines. With a genuine red wine the color produced is a grayish blue, which becomes lead-colored on drying. With magenta and other aniline colors it turns a carmine red; with ammoniacal cochineal, a pale violet; with elder berries, the petals of roses, etc., a green; with logwood and Brazil wood, the color of dregs of wine; with Fernambucca wood and phytolacca, a dirty yellow; with extract of indigo a deep blue. The manipulation required is very simple. A slip of the paper is steeped in pure wine for about five seconds, briskly shaken in order to remove the excess of liquid, and then placed on a sheet of white paper to serve as a standard. A second slip of the test paper is then steeped in the suspected wine in the same manner and laid beside the former. It is asserted that $\frac{1}{10000}$th of magenta is sufficient to give the paper a violet shade, whilst a larger quantity produces a carmine red. The inventors of the test paper, MM. Lainville and Roy, are also said to have discovered a method of removing magenta from wines, without injuring their quality—a fact of some importance if it be true that several hundred thousand hectolitres of wine sophisticated with magenta are in the hands of merchants.

THE NEW STAR.

By Prof. C. A. YOUNG.

PROBABLY every one of our readers knows that occasionally new stars have appeared in the sky, remained visible for a short time, and then vanished. The earliest recorded instance was in the year 134 B.C., and the occurrence is said to have led Hipparchus to make his catalogue of the stars, the first ever constructed, and the corner-stone of our modern stellar astronomy. Another star appeared in the reign of the emperor Honorius, about 389 A.D. It was near α Aquilæ, and for some three weeks was as bright as Venus. A third is reported to have appeared in the reign of the emperor Otho, about the year 945; and a fourth in the year 1264. With respect to these last two, however, there is room for doubt whether the accounts may not really refer to comets; they are not satisfactorily definite.

The most remarkable and brilliant of all on record was the fifth, the famous star of 1572, in Cassiopeia. It was first seen by Tycho Brahe, on Tuesday, the 11th of November of that year, and was then brighter than Jupiter; for a week or so it increased somewhat in brilliance until it exceeded Venus, and could be seen with the naked eye in full daylight; then it slowly declined, and after sixteen months, in March, 1574, became invisible. At first its color was clear white, then it became yellow; afterwards ruddy like Mars, and finally of a leaden hue, like Saturn.

Hardly less remarkable was the sixth of these stars, which blazed out on the 17th of October, 1604, in the constellation Ophiuchus. When Kepler first saw it, it was as bright as Jupiter. It soon began to wane, like the star of 1572, but did not entirely disappear for a whole year. Kepler was of opinion that it was generated from an ethereal substance pervading all space, and he remarked that the luminous ring (the corona) observed around the dark body of the moon during the total eclipse of the sun at Naples, in 1605, was occasioned by the existence of the same substance around the sun, a remark which in the light of the newest observations seems almost like a divination.

The seventh of these temporary stars was observed by Hind, in 1848, also in the constellation of Ophiuchus. The star when first noticed, on April 28th, was of the sixth magnitude, just visible to the naked eye. In about a week it brightened up to between the fourth and fifth, and then dwindled away, vanishing from sight about the end of May. It is still visible with the telescope as a star of the thirteenth magnitude—more than three thousand times fainter than when brightest.

The eighth of these objects made its appearance in the constellation of the Northern Crown, on the 12th of May, 1866. It was then of the second magnitude, as bright as the Pole star, but in ten days ran down to the sixth, the limit of unaided vision; it has been watched ever since, and is now of the eleventh magnitude, or nearly five thousand times fainter than at its maximum. Dr. Huggins succeeded in getting an observation upon its spectrum, and found it marked with the bright lines of hydrogen, and one or two other lines which he could not identify.

The ninth phenomenon of this kind has just occurred. On the evening of November 24, 1876, Professor Schmidt, of Athens, distinguished for his researches upon variable stars, observed in the constellation Cygnus a new star of the third magnitude, which by midnight was well up toward the second. On the 20th, the last clear night preceding, no such star had been visible. He immediately telegraphed his discovery to Paris and Vienna, but the weather was very unfavorable, so that no observation could be made until December 2, when the star had already fallen to the fifth magnitude; by the 12th it had become invisible to the eye—of the seventh magnitude, according to Hind—and it is now (January 10th) not above the eighth. The position of the star is near ν Cygni, in right ascension 21h. 36m. 50.4s., and in north declination 42° 16′ 38.5″, where none of the catalogues indicate any star at all; so that hitherto it cannot well have been brighter than the eleventh or twelfth magnitude.

On December 2d and 5th Cornu, the celebrated French physicist, obtained some very interesting observations upon its spectrum, using for the purpose the great equatorial of the Paris Observatory (fourteen inches' aperture) and a direct vision spectroscope, with a dispersive power about the same as that of the ordinary one-prism chemical spectroscope; the star being already too faint to allow the use of greater power. He found the spectrum to consist of numerous bright lines and bonds, standing out on a feebly luminous background which was almost interrupted between the green and the blue, so that the spectrum seemed at first sight to consist of two separate parts. If any dark lines existed they were too fine and faint to be seen with the power employed. Of the bright lines he succeeded in measuring pretty accurately eight, whose positions upon the scale of wave-lengths came out as follows, namely: (1), 661, (4), 588; (3), 531; (2), 517; (6), 500. (7), 483; (8), 451; (5), 435. The units of wave-length are millionths of a millimetre, and the prefixed numbers in parentheses denote the order of brightness. Three of these lines, (1), (7), and (5), are undoubtedly the lines C, F, and ν of hydrogen, whose wave-lengths are respectively 656, 486, and 434, the differences being no greater than would be expected in observations with such an instrument upon so feeble a light. Line (4) coincides with the sodium line D (λ* = 589) within the limits of error; and line (2) presents a similar agreement with the mean of the "b" group (λ = 517) due to magnesium.

"But the most curious coincidence," we quote the author's words, "which I give here with much reserve, but which it will be interesting ultimately to verify, is the coincidence of the line (3), very bright in the spectrum of the star, with the green line (λ = 432; 1474 of Kirchhoff's scale) observed in the spectrum of the solar corona, and in the chromosphere; the feeble line (8) corresponds also to a band (λ = 447) of the chromosphere; one is led thus to think that the line (4) corresponds rather to the bright line of the chromosphere, D, (λ = 578), helium, than to that of sodium. If this interpretation be correct, the bright lines of the spectrum of the star comprehend exclusively the brightest and most frequent lines of the chromosphere. The following, in fact, according to Young's catalogue of the chromospheric lines (*Philosophical Magazine*, November, 1871) is the designation of the brightest lines, and their relative occurrence:

Wave-lengths.	656 (C),	587 (D_3),	532,	517 (b),	486 (F),	447,	434 (h)
Relative frequence.	100,	100,	75,	15,	100,	75,	100.

"All the other bright lines have a relative frequency lower than 10 with the exception of the fourth bright line of hydrogen, h (λ = 410), whose relative frequency is represented by 100."

The case may be made even a little stronger; the only remaining line (6) corresponds to the mean of a group of

* λ is used as an abbreviation for the word wave-length.

lines (γ = 493 to 501) which, in the spectrum of the chromosphere, stand next to those already enumerated in frequency and brightness, as he would have seen if he had had before him the more complete catalogue of chromosphere lines published a year later. Resuming the quotation:

"To sum up, the light of the star appears to possess exactly the same composition as that of the solar envelope known as the chromosphere. Notwithstanding the great temptation there exists to draw from this fact inductions relative to the physical conditions of this new star, its temperature and the chemical reactions of which it may be the seat, I shall abstain from all comment and all hypothesis on this subject; I believe the facts necessary to arrive at a useful conclusion are wanting, or at least at a conclusion capable of verification. Whatever attractions these hypotheses may have, it is necessary not to forget that they are unscientific, and that, far from serving science, they greatly tend to trammel her."

This is undoubtedly true. It will not do to found a theory upon a single observation unsupported and uncontrolled by others. It is a pity that the news could not have been diffused more widely and rapidly among spectroscopic observers, for it is hardly to be expected now that we shall get from any other source observations suitable to compare with those of Cornu, and capable of corroborating or correcting them. Before coming to final conclusions we ought to hear from Huggins and Lockyer, Vogel and Secchi. The news did not reach this country until December 18th or 20th, when it was too late to do anything.

But even as the matter stands, the result is certainly most interesting and suggestive. It seems as if this most stupendous of all phenomena in the physical universe—this "conflagration of a world"—were likely to prove simply the same thing, on a larger scale, which in a small way is continually happening upon the surface of the sun. Whether the outburst in the two cases is due to similar causes we cannot tell.

In the solar eruptions the energy which operates is almost certainly internal; pent-up forces imprisoned within the body of the sun break out with more than volcanic violence. Is it so with the star? And if so, are we to think that some time our own sun may, as the result of forces now at work within his mass, blaze out in the same manner upon his attendant planets—the beautiful phenomena which we now observe with our spectroscopes, and admire from day to day, being only prelusive to the great catastrophe, like the mutterings which precede the earthquake? Or rather, and perhaps more probably, is this sudden flashing into light due to an encounter between the star and some unseen mass met by it in its swift course through space? Or shall we ascribe the strange occurrence to some action as yet quite beyond the reach of reasonable speculation?

In the present state of science we cannot say; but such phenomena are at all events most impressive in their teaching of the intense activity which pervades the universe. Of the sun and stars we naturally feel that they at least are permanent and unchanging, eternally calm and far beyond all turmoil. But closer study reveals the falsity of this; we find that they rush through space more swiftly than cannon balls; they vary in their brightness and color, and flush and faint like maidens. And yet, for the most part, their visible changes are such as can be detected only by patient and minute observation, because we who watch them are so small and far away, and our scale of time and magnitude so insignificant. Such an event, therefore, as we have been considering, may well arrest attention.—*Boston Journal of Chemistry.*

METHODS OF VENTILATION.*

MR. PRESIDENT,—In reporting upon the systems of ventilation, I have endeavored to obtain the results of experiments and experience of men of undoubted authority, such as Prof. Pettenkofer, Dr. Grassi, Peclet, Morin, and many others.

While much ingenuity is exercised, and the means employed to accomplish ventilation are various, the systems upon which they are based are known first as that of natural or spontaneous ventilation; second, of ventilation by aspiration or extraction; and third, that of propulsion or mechanical ventilation.

Natural ventilation is based upon the difference of the outer and inner temperature, and consequently also upon density of the interior and exterior air. To produce a sufficient velocity in the evacuating and supply flues so as to insure an efficient renewal of the air, the difference of temperature must be considerable. The primary force which produces motion in spontaneous ventilation is the difference of specific gravity of two columns of air. In the same degree that this difference of temperature is lessened between the inner and outer air, the velocity of the current will be reduced. Should the exterior air be equal in temperature to that of the interior of a building, no movements of air will take place.

Degen (*Handbuch der Ventilation und Heizung*) states that by a difference of from 30° to 40° a sufficient ventilation may be secured: a result that may be obtained in winter, but not in the spring, summer, or fall. "In these seasons," the same author says, "the system of natural ventilation has been found to be insufficient; and if a constantly operative ventilation is required, it will be necessary to employ mechanical means to secure it." It seems necessary in these seasons to employ machinery to set the air in motion: the opening of windows will not be sufficient. Pettenkofer found that through a window-opening of 9½ square feet a supply of only 14 cubic metres of air was received during one hour, and by the entire open space of an ordinary window, the requisite quantity for two persons only could be obtained (60 cubic metres per hour being considered necessary for one person). To demonstrate how variable the results are of natural ventilation, I need only refer to some of the experiments of Dr. Pettenkofer made during the months of March, October and December. At 19 different trials he found the changes of air in the same room, of which he was the only occupant, to vary from 66.3 to 1009.8 cubic feet. In the former case there was no difference between the exterior and interior temperature, while in the latter the difference was 19°. In addition to the above, Pettenkofer made 220 experiments in the Lying-in and in the General Hospitals at Munich, by request of the Bavarian Government. The ventilation of these buildings was based upon the natural system; he found during 100 experiments that it was entirely inoperative, and during 100 other experiments the action in the flues was the reverse of that which it was intended they should have.

This, then, seems to demonstrate the insufficiency of the system where a permanently active change and an unvarying supply of air are required, as in hospitals, asylums, prisons, schools, etc. In connection with this system, I wish to add yet that the velocity of the current of the exterior air exerts a marked influence upon the ventilation of a building, as it has been found that much more fuel and heat is required when it is cold and windy than during calm cold weather.

The second system is that of aspiration or extraction. This system has perhaps nowhere had a fairer trial than at the Hospital La Riboisière at Paris. This hospital was completed in 1854. The authorities, being very desirous that it should be well heated and ventilated, prepared a programme containing the conditions which should be fulfilled by proposals which were to be invited. The programme according to Dr. Grassi (*Étude comparative des Deux Systèmes de Chauffage et de Ventilation établis à l'Hôpital La Riboisière*), contains the following thirteen conditions:

1. A constant temperature of 15° in the wards during the whole year by day and night.
2. A temperature of 15° during the whole year, in the daytime only, in the offices and rooms.
3. A temperature of 10° the whole year by day and by night on the stairs of the pavilions of the sick.
4. A constantly operative ventilation by warm air in winter and by cold air in the warm season; the supply of fresh air to be at least 20 cubic metres per hour and per bed in the wards.
5. A ventilation during the daytime only of 10 cubic metres per bed in the private rooms of each pavilion.
6. A ventilation in the waterclosets sufficient to prevent under all circumstances the development of bad odors, and without creating currents which might prove injurious to the patients.
7. The ventilating apparatus to possess a surplus of power sufficient to produce in some or all of the wards twice the amount of ventilation before prescribed, in case it should be found necessary during a great epidemic to increase the number of beds.
8. The ingress openings of the fresh air flues to be of sufficient transverse section to admit the air into the wards with but little current, and at a temperature not exceeding 70°.
9. The air must enter the wards in the requisite degree of moisture, susceptible, however, of being changed at pleasure.
10. An especial contrivance for cooling the air artificially when necessary during seasons of great heat.
11. The apparatus for the general heating, or special apparatus, to furnish a sufficient quantity of warm water to answer all requirements of the wards, and to maintain an efficient temperature in the hot closets of the ward kitchens.
12. In every kitchen of the basements, either in connection with the warming apparatus of the kitchens of the upper stories or separately, provision must be made for maintaining an active fire.
13. The heating and ventilating apparatus to be contrived so as to admit of being gradually put in operation in all parts of, or to be discontinued in any portion of, the buildings; besides, the apparatus must permit the lowering or raising of temperature of the wards.

A commission composed of scientific men of accepted authority, and presided over by the well-known physicist and chemist Régnault, examined the various proposed plans and methods, and decided in favor of forced or fan ventilation, as proposed by Thomas and Laurens of London. This decision created a general dissatisfaction and strong opposition. This method had not been in use in Paris. The system of aspiration, so well contrived by Léon Duvoir, had produced favorable though not entirely satisfactory results; but its advocates so strongly attacked the decision of the commission, that a second one was formed, composed mostly of architects, under the presidency of Gen. Morin. The latter made the proposition, assented to by his associates, to heat one half of the number of pavilions by the system of aspiration as proposed by Léon Duvoir, and the other half by the system of propulsion as proposed by Thomas and Laurens. The demand upon the ventilation was increased from 20 to 60 cubic metres per hour and bed for both systems.

It has been conceded that the operation of these two systems was investigated in a most thoroughly scientific and impartial manner by Dr. Grassi during a period of two years. In the experiments of the system of aspiration he put to himself several questions, which, in the opinion of Pettenkofer, were answered with scientific precision. Among these were first: Is the amount of air which passes through the extracting chimney equal to the amount of fresh air supplied by the flues intended for this purpose? By measuring with the anemometer he found that 93 cubic metres of foul air passed through the chimney per hour and per bed, while only 31 cubic metres of fresh air came in during the same time through the fresh air flues instead of 60 cubic metres as prescribed, and the difference of quantity was supplied by the doors and windows.

Dr. Grassi found during various experiments an analogous result. Question second: Is the system of aspiration uniform during the entire year?

The result of his experiments obliged him to answer this question most decidedly in the negative. The motive power being the difference of temperature of the extracting chimney and that of the open air, and as this difference was at times more, and at other times less, so also he found the ventilation to vary. Consequently the system of aspiration was declared by Dr. Grassi to be faulty and insufficient.

In connection with the system of aspiration the construction of the ventilating shafts, flues, and chimneys is of great importance. I have learned by experience that it is not sufficiently observed by people who have such matters in charge, whether the movements of air are produced by static pressure or by suction.

It is ultimately the general pressure of the atmosphere which produces the movements of air, whether in consequence of the disturbed equilibrium, or by a vacuum created by suction. A chimney-flue does not act as a bellows; and the general expression "suction of the air" by means of a chimney shows most unmistakably the erroneous conception of aerostatic laws by laymen in physics. Physicists have furnished the most decisive proofs that the so-called draught in a chimney is not produced by the tendency of the warmer columns of air to rise within it, but by the pressure of the colder lower strata of air; for the same reason that causes oil to rise in the water.

The third system, that of propulsion, being in use in the other half of the La Riboisière Hospital buildings, was submitted to the same careful test by Dr. Grassi. While the programme demanded a supply of only 60 cubic metres per hour and bed, he found that in the pavilion nearest the fan 132 cubic metres were furnished per hour and bed, in the second 126 cubic metres, in the third and last 88 cubic metres were furnished, or an average supply of about double the quantity demanded.

Grassi tested also the barometric pressure of the air in the wards in comparison with that of the open air, and found the former less compressed than the latter, so that considerable additional air passed into the wards by the joints of the windows and doors. Notwithstanding the excessive supply of air, no draughts or unpleasant currents were perceptible a few feet from the openings.

It was also found that in the wards ventilated by this system the carbonic acid was only 11 per thousand, while in the former it was 2.5 per thousand of the volume of air.

Dr. Pettenkofer, who was commissioned by the Bavarian Government to examine the ventilation in use in the public buildings in Paris and London, has verified the conclusions of Dr. Grassi, and states in his report that the experience and tests made at La Riboisière were perfectly convincing as to the superiority of the system of propulsion or mechanical force in ventilation, and recommends it as the only reliable method.

As it has been a point of considerable dispute and discussion whether a fan should be placed so as to extract the foul air, or to force in the fresh air, Dr. Pettenkofer gives the results of experience as well as investigation of this matter at the Hospital Beaujon in Paris. Here the fan was originally placed in a chamber in which all the foul air flues terminated, and contrived so as to extract the foul air, leaving the supply of fresh air to take care of itself. This, however, proved a complete failure, and it was found necessary to change the position of the fan, and reverse its operation so as to force in fresh air.

Dr. Pettenkofer closes his report with the opinion that the natural system of ventilation is irregular and accidental, and not to be recommended. As to the system of aspiration, he says that it cannot be denied that a good ventilation may be attained by it, but it is more or less irregular, and will vary with the difference of temperature in the extracting chimney and that of the open air. He refers to Peclet as having given the clearest and most convincing proofs of this in his report of the ventilation of Mazas Prison. He concludes by recommending forced ventilation as the only reliable method, inasmuch as the requirements of our lungs are constantly the same, that it is our duty to employ the means by which we will insure the supply of this demand. He says that it is of the utmost importance to furnish a sufficient supply of fresh air, and when this is done but little attention need be paid to the expulsion of the foul air.

Peclet, who devoted a lifetime to the study of physical science, who has sometimes been called the father of the new science of applied physics, and whose works are perhaps the most authentic on everything that appertains to the phenomenon of heat, has expressed almost the same views as Dr. Pettenkofer. (The views of Peclet have been cited in Dr. Parke's "Practical Hygiene.")

Gen. Morin in his latest work upon heating and ventilation gives the results of investigations in these matters in several of the manufacturing establishments of Paris, where the atmospheric impurities produced were very great, "as showing that the recent trials seem to demonstrate that the system of ventilation by propulsion was the most effective." A German author in reviewing Gen. Morin's work, and noticing this passage, says, "The advocates of this method could not desire a better method than this, as it comes from a hitherto most strenuous opponent of that system."

Dr. Seifert of Dresden, to whom was awarded the first prize by the Imperial Academy of Vienna for an essay on the construction of Asylums for the Insane, and who visited the institutions of Germany, France, England, and other countries, arrived also at the conclusion that mechanical ventilation was the most perfect.

The convention of Superintendents of American Asylums for the Insane, declared by resolution in 1851, and re-affirmed the same in May, 1853, that forced ventilation or the use of a fan was the only method to be recommended for their institutions.

HEALTH AND SEWAGE OF TOWNS.

IN a recent address, the Chairman of the Society of Arts, London, said:

How to deal with our sewage, and how to get rid of the nuisance at the smallest possible cost, and with the greatest advantage to health, is a difficulty which still confronts us. Exaggerated notions at one time prevailed as to the fertilizing value of the sewage, and there was a popular belief that, in lieu of a burden on the ratepayer, it would become a source of wealth to each town. Scheme after scheme was propounded on this supposition, but only disappointment followed. Chemical analysis, it is true, showed certain valuable fertilizing constituents and fostered delusion, no account being taken of the cost at which they could be secured, even if any process had been discovered by which they could be made available. Experience, however, has led to the entertainment of more sober views, and the public are now beginning to learn that profit must not be looked for. Our health and comfort demand that the nuisance must be got rid of in some way or other, and at any reasonable cost; and if by some method of treatment a return can be obtained to diminish this cost, so much the better. We are no longer permitted to pollute our streams with it, and other means must be adopted for the removal of and dealing with our sewage. Experience would seem to show, and our conference enforced this lesson, that perhaps a profitable as well as healthful way of dealing with sewage is to apply it to the land; but, unfortunately, it is not every locality that can supply, at a reasonable price, land suited for the purpose, either in soil or position. There are, doubtless, various processes for treatment of the sewage, chemically and by precipitation, which result in the production of a good effluent, generally sufficient to meet the requirements of the Act, but the precipitant, sludge, or solid matter produced, is but of little value, and must not be reckoned upon as giving a return in money covering the outlay for works and cost of carrying out the process. At Leeds, I understand, where, probably, a larger amount of practical experience has been obtained on an extended large scale than in any other town, the difficulty has been to get rid of this sludge or solid matter; and it is only within the last few weeks that arrangements have been made with a contractor to purchase it and take it away at 12s. per ton, a sum totally inadequate to defray the cost of treatment. All that can be looked for in any case, wherever the water-carried sewage is applied to land, or treated by any known process, is that, under the most favorable conditions, some small return may be obtained in diminution of the necessary cost of getting rid of the nuisance.

* [Report on Methods of Ventilation, read at the Third Annual Convention of the American Public Health Association, at Baltimore, by Carl Pfeiffer, Consulting Architect of the Health Department, New York.]

NEW INVESTIGATIONS ON GLOBULAR LIGHTNING.

By M. GASTON PLANTÉ,

IN the course of previous researches, I have had occasion to observe phenomena of dynamic electricity presenting analogies to globular lightning. My experiments show that with discharges produced by an electric current, of high tension, furnishing a quantity of electricity which statical electric or induction apparatus could not give, there is obtained by the contact of the positive pole with the surface of a liquid, and without very sensible electrolytic decomposition, a formation of luminous globules, having a gyratory movement, followed, under certain conditions, by brilliant sparks at the negative pole. From this it has been concluded that an analogous effect might take place during great storms, when atmospheric electricity exists in exceptional quantity, so as to constitute by its continuous discharges a sort of dynamic flux, and more especially when the atmosphere is traversed by abundant rain, which facilitates the formation of spheroids of electrified watery vapor.

These conditions were actually realized during a violent tempest which burst over Paris on July 24, 1876. At about 4 P.M. torrents of rain, mingled with large hail, descended. There was little wind, and the stormclouds remained almost stationary for some time. The lightning flashes were incessant, and several strokes occurred in the city—three being noted almost at the same point. It was near the Theatre Beaumarchais that a globe of fire, as represented in Fig. 1 (extracted from *La Nature*), was seen to fall. In the Rue des Tournelles, another globe, about the size of a cannon ball, struck a roof beside a flower-pot, and injuring but a single stalk of the plant therein, rolled off into the court below. At the same moment another observer on the ground floor saw three balls of fire above the completely inundated ground of the courtyard, Still another observer witnessed two or three fiery masses descend in his garden, which likewise had been converted into a pool of water. These masses were, however, without definite shape, and appeared as represented in Fig. 2. In the case illustrated in Fig. 1, the discharge seems to have been attracted by the high metal chimneys, whence it passed to the roof, tearing off a small scrap of zinc, and then descending lit the gas which was escaping from a tube, at A, over the inner door. No other damage was produced.

The formation of globular lightning, judging from these phenomena, in connection with my preceding investigations, may be explained as follows:

1. The electric current in traversing the moist atmosphere produces a partial vacuum, resulting from its powerful calorific action, and from the vaporization of all matter which obstructs its passage. Through this aspiratory effect the matter itself tends to assume a spherical or globular form, the same as the liquid in the voltameter in the experiment referred to in the beginning, or, generally speaking, as any liquid mass does when the action of gravity thereon is rendered null.

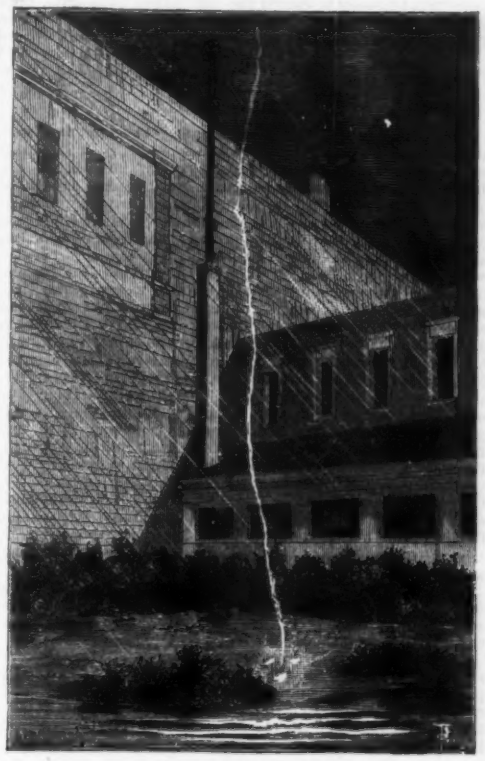
2. The ponderable matter thus reduced to globular state necessarily becomes highly rarefied, since this rarefaction is the consequence of the passage of a powerful electric current. Taken, as the matter is, from the surrounding medium, it s ould be composed of air and water vapor. It doubtless also contains some traces of gas, due to weak

GLOBULAR LIGHTNING.

electrolytic decomposition; but, as the calorific and luminous effects are here predominant through the high tension of the atmospheric electricity, the electrolysis is scarcely sensible, and to the detonating mixture formed by the gases cannot be attributed the explosive phenomena of the fulminating globes.

3. The electric current accumulates in this envelope or medium of rarefied matter, and renders visible its spherical form by the light which it produces. There is therefore formed a kind of luminous *electric egg*, which the surrounding atmosphere tends, it is true, to fill; but if this medium is not too dense, like air or watery vapor, the abundance of the electric current rarefies the matter in proportion as it electrifies it.

4. In order to conceive of this accumulation, or this condensation, of electricity in the fulminating globes, it must be considered that, if the electric flow exists in great quantity in the atmosphere, the violence with which it passes is such that no road is large enough to allow of its easy and complete dispersion. Wherever it is opposed, there it concentrates. Now, the more or less humid strata in the atmosphere present very great inequalities of resistance; on the other hand, the portion of the atmosphere interposed between the electrified cloud and the soil may act as an isolating plate, like that of a condenser, or like the liquid of the voltameter. The soil becoming strongly negative, admitting that the stormcloud be charged with positive electricity, it follows that the electricity tends to accumulate at the separating surface, and the points where this accumulation is produced greatest may give rise to the fulminating globes.



GLOBULAR LIGHTNING.

5. This assimilation of the atmosphere to the isolating plate of a condenser enables us also to understand how the globes, formed either in the clouds or near the earth, may be dissipated without noise, or discharged without explosion. Since the soil is strongly negative under the influence of the electrified cloud, this negative electricity produces equilibrium, through the atmosphere, with the positive electricity accumulated in the globes. If the accumulation ceases, through the insufficiency of the electric current, the globe may noiselessly disappear. If, on the contrary, the electric current tends constantly to accumulate new quantities of positive electricity in the globe, this electricity eventually acquires very high tension. The atmosphere is then traversed like the glass of a Leyden jar too highly charged, and the discharge takes place with an explosion. These phenomena are reproduced in the voltameter submitted to the action of a current of high tension, by simply varying the degree of immersion of the positive or negative electrode.

6. The abundance with which the electric current must flow in order to produce these local accumulations of electricity in the globes, explains how lightning rods are often inefficacious against the stroke of globular lightning. It may be concluded that, in order to neutralize this species of atmospheric electricity, lightning rods presenting a great number of points would be the most suitable, and much better than high rods presenting but one point each.

7. The gyratory movement noted in the globes results in the same manner as that in the luminous globules formed at the surface of the voltameter liquid, from the reaction due to he escaping of the electric current, or from the watery vapor which it produces. In the voltameter experiment the direction of this motion is variable, and depends on that of the current when no magnetic influence intervenes; but, if a magnet is introduced, the movement occurs in a determinate sense, the inverse of that of the hands of a watch. It may be deduced from this that in nature, under the unceasing influence of the earth's magnetism, this gyratory movement should take place, like that of cyclones, contrary to the watch hands, above the northern hemisphere. This consequence it may be interesting to observers actually to verify.

8. The rustling noise which sometimes accompanies the apparition of the globes is equally notable in the experiment above cited, and is due to the rapid vaporization produced by the calorific intensity of the current.

9. In order to account for the accumulation of electricity in the globes, and to explain their singular travel, they may be compared to water or dust spouts, having great rotary velocity, but which present curious effects of composition, of motion, and resistance to the action of gravity. There is this distinction, however, specially to be observed, and that is, that the movement in the globes is not a rotary one, but a mode of vibratory motion extremely rapid, and constituting the electricity itself, and which, on the other hand, should not be confounded with the gyratory movement due, as above explained, to reaction.

In the same way, also, whirlwinds or waterspouts, owing to their great velocity of rotation, may destroy the bodies which they strike, or break themselves against fixed objects which suddenly arrest their motion, just as the globes may explode when the internal vibratory movement is abruptly arrested or neutralized. But it is only a rupture of electric equilibrium in the soil or in the atmosphere that can produce this effect, and if no such change takes place the globes remain insensible to the contact of foreign bodies placed at the surface of the soil, which they meet during their passage.

Thus are explained the strange movements of the fulminating lightning balls, their apparent defiance of the laws of gravity, their irregular velocity, and their innocuity in certain cases, or their destructive effects, accompanied by all the phenomena which characterize the expansion of the electric force.

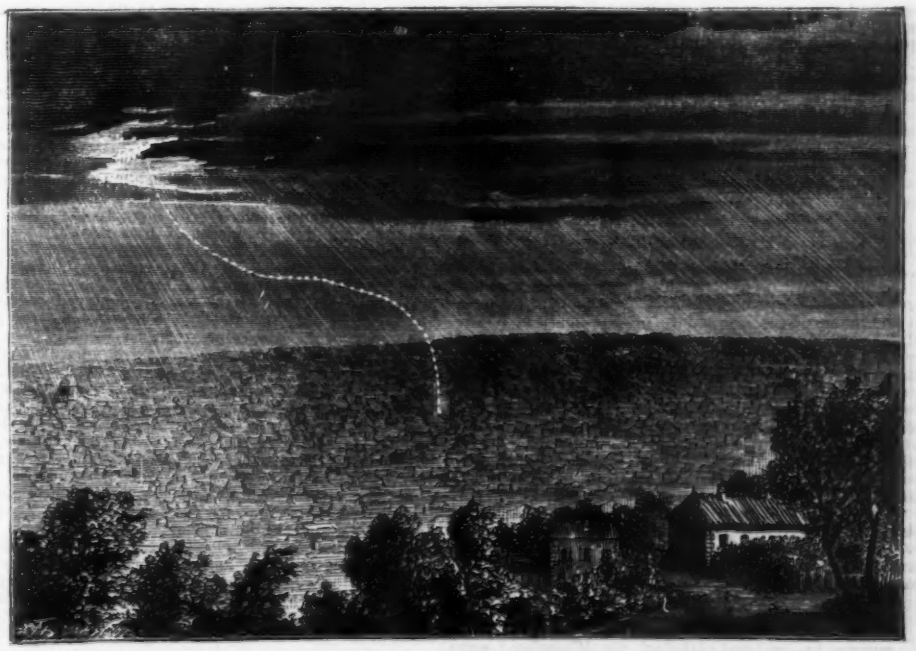
CHAPLET LIGHTNING.

DURING a severe storm which burst over Paris, France, on August 18th, 1876, M. Gaston Planté reports having observed a lightning flash of a type which is extremely rare, not classified by meteorologists, and which tends still further to explain the formation of globular lightning. The vast cloud which overhung the city had already given forth numerous flashes, some bifurcated, others in multiple curves, all of which seemed to be composed of brilliant points similar to the fiery dashes produced on a moist surface by an electrical current of high tension, Suddenly a flash, more intense and more lasting than the others, appeared in the form of an elongated S, as shown in the annexed engraving. It consisted of a narrow, luminous filament, covered with a garland of brilliant spots.

The part of the city toward which the end of the S tended experienced lightning strokes in many localities. The rain was very abundant, so that the air was saturated with watery vapor.

M. Planté considers that the formation of luminous spots, alternating with fiery traces, is a consequence of the flow of the electric current through a ponderable medium, and quite analogous either to the chaplet of incandescent globules which a long metallic wire presents when melted by the voltaic current while its extremities remain in a state of fusion, for an instant suspended between the poles of the battery; or to the swellings or nodes resulting from the flow of any liquid vein. Such agglomerations of electrified and luminous matter should naturally be slower in dissipating than the luminous track which unites them, and thus is explained the persistence of the observed flash.

This kind of lightning constitutes an indicative phenomenon which shows the transition of the ordinary form of sinuous or rectilinear lines into the globular form. It may be conceived that if the electrical condensation on some points of the trajectory of the flash is more considerable, the spots may acquire a certain volume, and thus produce globes remaining visible for some time. Thus fulminating globes may be considered as derived from chaplet lightning, and, if the luminous track be not seen with them at the points where they appear, it simply follows that our proximity prevents our seeing the whole of the phenomenon, as is not the case when we regard the same from a distance.



CHAPLET LIGHTNING.

GOLD NUGGETS.

THE largest lump of gold ever discovered—it was called the "Welcome" nugget—was found at Ballarat, in Australia, in June, 1858. It weighed 184 pounds troy, and was worth $32,000. The Melbourne *Herald*, June 19, 1858, says that it was found 190 feet below the surface of the earth in a chain which had yielded many other nuggets weighing from 10 to 45 oz. It is thus described:

"A large misshapen, irregular lump of gold, waterworn and rounded on each of the numerous edges presented by a surface completely and more or less deeply honeycombed. Its length is about 20 inches, its greatest breadth about 12 inches, and its greatest depth about 8 inches."

If it were a right-angled body of these extreme dimensions, its cubical contents would have been 1½ feet. A cubic foot of solid gold, pure, would be worth $262,600. A cubic foot of gold of the fineness of the United States gold coins—that is to say, nine-tenths alloy—would be worth as gold $236,334.

Another Australian nugget found at Korong, in 1857, weighed 145 pounds, and was estimated to be worth $35,000. It was a solid mass of gold, approaching the shape of a bar, two feet four inches long, ten inches broad, and from one to two inches thick.

A lump of gold was found at Cabarras county, N. C., in 1842, which weighed 84 pounds. If pure, its value would have been nearly $20,000.

A nugget weighing 93 pounds is reported to have been found in the Valley of Taschku-Taranka, in Siberia, also in 1842.

The nugget second in size among fully authenticated discoveries, was found in Calaveras county, Cal., in 1854. It weighed 161 pounds avoirdupois, but being estimated to contain 20 pounds of quartz, was valued at no more than $29,000. The gold of California, as then mined, carried as an average one-tenth of silver. The Australian gold is much nearer pure. This accounts for the discrepancy in relative value of the Calaveras nuggets as compared with the Australian one first mentioned above.

A thousand nuggets weighing a pound each, according to Mr. Hittell's estimate made in 1860, had been found in California. Fifty of these weighed over 20 pounds each. The number of lumps ranging from 1 to 16 ounces has been great. The vicinity of Sonora, in Tuolumne county, was the region of California most prolific in nuggets.—*Mining Review.*

ENSTATITE.

PETTERSEN writes a letter to the *Jahrbuch für Mineralogie*, describing his discovery of nearly pure enstatite on the Slunkas Berg, in Nordland. Fragments, both large and small, as well as blocks, of this mineral were found on the summit of the mountain lying loose on the surface, and, although a careful examination was instituted, in no case could any portion be met with *in* the rocks of the area over which they were spread. The mineral had a brownish nodular surface, and appeared to be somewhat weathered; the interior was of a grayish green color, and had a coarsely foliated structure, on which two crystals or cleavage planes were observed. The enstatite was often coated with and occasionally penetrated by white crystalline granular magnesite, which did not contain even a trace of lime; this magnesite was evidently the result of metamorphic action. Disseminated through the enstatite, and in some instances through the magnesite, small black granules were noticed which were strongly magnetic, and contained chromium; whether magnetite as well as chromite was present could not be determined. No serpentine rock nor one of an olivinous character, with one or other of which, as might be expected, the enstatite would be associated, could anywhere be traced. The author suggests, as an explanation of the occurrence of these remarkable masses, that they may have a cosmical origin, in which case they would have to be included in that class of meteorites to which Daubrée has given the name "Cryptosiderites." The specific gravity of this enstatite, it should be stated, was found to be 3·22.—*Academy.*

TRIDYMITE.

VOM RATH has met with this mineral in considerable abundance in the andesite of Gerecses, Csik-Magos Mountain, in East Siebenbürgen (*Jahrbuch für Mineralogie*). The rock has a gray color, and resembles phonolyte; the few embedded crystals are plagioclase; numberless small points of magnetite are to be observed in it. That it is not phonolyte is shown by the manner in which it is acted upon by acid. Along the directions which indicate its foliated structure numerous flat cavities are seen enclosing crystals of tridymite, some 1 mm. across, and exhibiting the characteristic twinned forms. Such an abundance of this form of silica has probably been met with in but few rock structures. Baltzer, it will be remembered, who studied the volcanic eruption which occurred in Vulcano in 1873 and 1874, found among the erupted matter a snow-white ash which contained 94 per cent. of silicic acid, mixed with chlorides and sulphates of the alkalies and alkaline earths, etc. The silica of this ash is to a great extent in the form of tridymite. It is supposed that it was originally in an amorphous modification, and by the action of high temperature and acid vapors was transformed into tridymite.—*Academy.*

PYROSMALITE.

A COMPLETE analysis of this remarkable mineral has now, for the first time, been made by Ludwig, who has employed for that purpose some of the specimens of the recent find in one of the iron mines of Nordmark in Wermland, Sweden (*Ann. der Chemie*). He finds as the result of a number of confirmatory analysis that the whole of the iron is in the state of protoxide, and that the empirical formula of the mineral is $Si_4Fe_6Mn_2H_{14}O_{18}Cl_2$. In respect to the constitution of the pyrosmalite, it may be regarded as consisting of eight molecules of normal silicic hydrate H_4SiO_4; of the thirty-two atoms of hydrogen in this group fourteen are actually present, and in place of the remaining eighteen we have ten atoms of iron (and manganese) in the form of protoxide, but of these twenty "units of neutralization" two are "saturated" with chlorine and the remaining eighteen replace the eighteen hydrogen atoms, just referred to. The new specimens of the mineral are in the form of fine large hexagonal prisms, lustrous on the surface, and presenting no signs of weathering.—*Academy.*

POLYDYMITE.

LASPEYRES has analyzed (*Jahrbuch für Mineralogie*) some specimens of nickel ore occurring in fine polysynthetic twins of tesseral octahedra which, on comparison with other specimens in the Aix-la-Chapelle and Giessen Collections, appear to have come from the Grünau mine in Sayn-Altenkirchen, whence Von Kobell obtained forty years since the nickel bismuth glance which has received the names grünauite and saynite. Laspeyres' examination showed the mineral to consist of four atoms of nickel (with a little iron and a trace of cobalt) and five atoms of sulphur. The ratio R_4S_5 has hitherto only been met with in the sulphides or arsenic and antimony. It occurred to Laspeyres that Von Kobell's mineral might not be a chemical compound, but a mixture of bismuth glance with the new sulphide of nickel which he has discovered, and on examining a specimen collected by Von Kobell at Grünau at the earlier date he found this view to be correct. Laspeyres proposes to cancel the old names grünauite, saynite and nickel bismuth glance, and to give the name "polydymite" to this curious nickel sulphide.—*Academy.*

CORUNDUM AND ITS GEMS.*

By CHARLES W. JENKS.

CORUNDUM, in its granular as well as gem forms, has been known to the world from a very early period. In the first, used as an abrasive, second only in cutting qualities to the diamond; and in gems, as sapphire, ruby, asteria, etc., nine in number, some of which to-day outrank in value, as they have ever done, the costliest diamonds. I shall show you some of these this evening; specially one, locked up in its native matrix, which, could it be liberated and be perfectly cut as a gem, would, in the market of London, sell for five times the price of a diamond of the first water of the same size. In fact, it would, so far as is known, have but one competitor in Europe, according to Mr. Harry Emanuel, a great authority there in such matters, who says: "I know of but one corundum emerald now in existence: it is the rarest of all gems, and the most valuable." It is its extreme rarity, and the nature of its composition, pure alumina, giving it so much greater hardness and brilliancy, which gives it this great value. The emerald of commerce from Peru and Bogota is largely silica, of course softer and quite common. From a date as early as Solomon, the corundum gem localities have been known and worked in Armenia, Bactria, India, Ceylon, and elsewhere. The extreme beauty of these gems early invested them with a powerful talismanic influence in the minds of their owners; and greed for their possession involved several of the Oriental nations in costly wars and much bloodshed.

Moses, by divine command, enshrined them in permanent form over the heart of the Great High Priest, where their brilliant scintillations, in some mode unknown to us, voiced the will of Jehovah himself.

In granular form, corundum was known to the Persians as Armenian stone; to the Chinese, as adamant; and to the people of India, as corundum, from the Hindoo word *korunda*, or cinnamon stone, so called from the resemblance in color to that article of the variety found in that country. By this latter name, the mineral is now known, from whatever locality it comes. It is widely scattered over the earth's surface; and yet, though for more than two thousand years used extensively as an abrasive, it has not, so far as I can ascertain, until the past five years, been legitimately mined. In the ravines of the mountains in Siberia, China, and Hindostan, it is gathered by the natives in small crystals after the rains; but it is not now, nor ever has, so far as we have evidence, been sought for at much depth beneath the surface. In India, hitherto the chief source of supply, it is, like most of the industries there, of caste production; and of its localities, methods of development, and amount of product, it is very difficult to gain information. Sir Charles Greville, of London, about the year 1798, in company with Count Bournon, of Paris, prepared an elaborate paper for the Royal Society of London upon this subject. Sir Charles visited one of the localities in India, but nowhere saw the mineral in position, or in much quantity; the natives working in trenches, and finding scattered masses here and there, with no evidence of vein formation. The gems have always been sought for by similar methods in the beds of streams or on the banks of the same. This is the character of the mining to-day for both classes of the mineral in all the noted localities of the old world.

Emery, one variety of corundum, as is well known to you, is extensively mined among the islands of the Ægean Sea, in Asia Minor near Ephesus, and in an impure form at two or three points in our own country. A paper upon this mineral, and the first where it had received thorough scientific attention, was read some twenty-five years since, before the French Academy, by one of America's most distinguished scholars—Dr. J. Lawrence Smith, of Louisville, Ky.

It has always seemed strange to me that so little was certainly known of corundum; long used, next the diamond in cutting power, and always in some of its forms more prized as an ornament than that so-called "king of gems!"

In their size, brilliancy, color, and artistic execution, there are no modern precious stones of this mineral equal to those that have come down to us from an early age. May it not be possible, also, that, in its granular forms, its mining and uses have been among the "lost arts," so eloquently described by Phillips? During the first French empire, the emperor placed an obelisk from the banks of the Nile in the Place de la Concorde. Wishing to inscribe the date of its removal upon its base, his workmen destroyed, in their labors, several sets of the best steel tools, but failed in their purpose. Yet the same column is covered with hieroglyphics, from tip to base, by the skill of the workmen three thousand years ago. I believe there are but two—and those unimportant—well-authenticated instances of the occurrence of the harder metals, as found mid the ruins of Egypt by modern explorers. What were, then, the tools the ancients employed so skillfully? On the other side the Red Sea, whence came the harder monuments of the Nile valley, there has recently been found corundum, with all the indications of ancient workings. From this locality, may not these early artizans, "skilled in all the wisdom of the Egyptians," have found their tools, with which to execute thousands of square yards of exquisite workmanship with seeming ease, to imitate a few lines of which, successfully, exhausted the resources of the mechanics of Napoleon Bonaparte. Be this as it may, a workman in the near city of Worcester has invented a formula by which he has given us for exhibition this evening a wheel of corundum that will cut not only the granites of old Egypt, but even the diamonds of old Golconda!

It has been said in England that "a good mine of emery is worth more to a manufacturing people than many mines of gold." But emery is only valuable for its cutting properties: what gives it these is its possession of forty to fifty per cent. of corundum. In the scale of hardness, with the diamond at the head as 10°, the best emery stands at 7°. But corundum stands 9°, but one degree below the hardest known substance. There is a vast and constantly increasing field of labor, which the best emery can occupy but poorly, if at all; and the diamond, even with the great influx from South Africa, is much too expensive for general uses. Two-thirds of the gap between emery and the diamond is filled by the qualities of the mineral we are discussing; and the other third is being lessened by better modes of forming corundum for use, by rapid friction, and the immensely less cost of this abrasive for the uses of the larger industries.

Among these industries, in granite, steel, the new alloys, etc., there is a call for a tool that will do the work of the diamond, but of moderate cost.

I have just cut from a scientific journal the following article:

"With the new alloys for gun metal, rolls for paper-making machinery, the finishing more rapidly, plane surfaces in iron, steel, etc., there comes a demand for a new tool of harder material than any now in use. This demand has made itself known in Paris by an offer of three thousand francs as a prize from the 'National Society for the Encouragement of Industry,' the offer to hold good until the next great Exhibition in France in 1878."

In this connection allow also the reading of a brief extract from the London *Times* on the novelties and triumphs of American machinery as illustrated in the late International Exposition:

"New agents have been wanted to give a true surface to chilled iron or hard cast-steel. They are to be seen in W. Sellers & Co.'s planers and drill-grinding contrivances. The agent is the emery-wheel of the lapidary, not by the old haphazard system, but by well-defined movement. Their work, as a whole, should teach a lesson not to be forgotten to every competing nation."

These communications recognize the necessity of some new agent which, by its superior hardness and cutting power, shall add both speed and accuracy to execution. Any form of the diamond now known is altogether too expensive for extensive consumption. But very close upon it comes corundum, which can be supplied in quantity and but little above the price of emery, and in all the forms in which that mineral is used. Could the writer in the *Times* have seen the operation of the corundum wheel, in bringing to an even surface a chilled iron calender for paper-making machinery, his surprise would have been great indeed; for it is difficult to conceive, even with the diamond, of more rapid or perfect execution. One form of tool has been spoken of as of recent invention. It is the wheel I now show you—the work of Mr. F. B. Norton, of Worcester, Mass., made by him of nearly pure corundum, and which he calls the "Sapphire wheel." It runs and does its work equally well, wet or dry; water, heat, or acids having no perceptible effect upon it. It cuts cast iron, scale steel, chilled iron, any alloy, granite, etc., with much freedom. One of its best tests is the bringing of a steel tool rapidly to a cutting edge, without heat or loss of temper. This is due to its free cutting qualities, giving in the operation but little friction.

We have with us Mr. Samuel Reynolds, of this city, I believe the oldest, and certainly one of the most intelligent as well as skillful, lapidaries of this country. His testimony as to corundum as an abrasive corroborates all I have said; and also, as to the execution of the "Sapphire wheel," he gives the same testimony, he having cut even the diamond with the wheel before us.

Put into the form of this wheel, or used in any other that lapidaries or workers in metals employ, corundum will do thirty per cent. more work than the best emery, much work that emery cannot do at all, and not a small portion of the labor now done by diamonds in various forms.

I make this assertion with numerous indorsements, one of which I will give you, that of Col. J. G. Benton, commanding at the U. S. Arsenal, Springfield, Mass., who says:

"In one hundred days' work, corundum gives us a saving over the best emery of about forty-six per cent."

We have seen some of the uses and advantages of the mineral under consideration as an abrasive or cutting agent: a few words as to its gem characteristics, with a description of the mining locality where found, and I leave the matter in your hands for inquiry or discussion.

THE NORTH CAROLINA CORUNDUM MINES.

The corundum gems are nine in number. They are designated by the prefix "Oriental," because first known as coming from the East, their superior hardness and brilliancy, and because some gems of the same name are of an entirely different mineral They are called the Oriental sapphire, ruby, asteria, emerald, topaz, amethyst, girasol, chatoyant, and white or colorless sapphire, this last very often used in place of the diamond. These, all of greater or less purity, have been found in the locality we show you in this sketch, which is among the Blue Ridge Mountains in Western North Carolina.

This section of our country is exceedingly beautiful in its scenery, with a climate, even at the elevation of the mine—three thousand feet above tide-water—much like that of South Europe.

In the old-world localities, corundum in massive form and the gems, are not found in the same neighborhood. It has been the generally entertained opinion among men of science that the geological and mineralogical conditions of the two forms of the mineral were so unlike that it was not probable they would anywhere be found together, or near each other. Nature in our hemisphere shows a different development, certainly in North Carolina, where we find both forms in the same mountain.

All the gem localities of the East where colored corundums are looked for, are, as has been said, in the beds of the streams, or in the banks on and near them. This is the case in India, Ceylon, Bactria, the Ural, China, etc. In fact, so uniform had the experience been in this direction that authorities, from Pliny to the present date, were quite united in the view these stones were to be looked for only in the secondary formations, and as water-worn gems. Count Bournon, Cuvier, Buffon, Haüy, Sir Jas. Bruce, and others give this view. Sir Samuel Baker and Judge Mitford, British judge of Ceylon, both of whom have resided many years in that island, and mined extensively for sapphires, use, in their recently published works, this language: "It is our opinion the sapphires were created in the peculiar secondary formations, where they are always found as water-worn pebbles, in a conglomerate of blue and white clay," etc.

I have never found a lapidary in Europe or this country, who had seen the corundum gems in any form not subjected to water action; and I have never seen in any cabinet, here or abroad, corundums of pure color and sharp angles from any locality but the North Carolina mine.

We shall show you some of these gems which have been found there on the surface, in the beds of the streams, and at depths of from ten to seventy-five feet, yet three thousand

* A paper read before the Society of Arts, Technological Institute, Boston, Dec., 1876.

feet above the sea level. Some were in their native matrix of ripidolite, between hanging and foot walls of serpentine, apparently undisturbed, and yet with all the appearance of water action; some as clear perfect crystals, with outlines as sharp as though created but yesterday; others as transparent nodules in a matrix of laminated corundum, which, had they been exposed to water action, undoubtedly would have disintegrated and have left the pure gem nodule, as found in Ceylon and elsewhere; others were found singly or in groups locked up in geodes of chlorite, from the size of a hen's egg to a fifty-pound shot; and others still in pockets of partially changed or decaying schists of mica and talc. In a pocket of this latter, the workmen one morning uncovered a crystal perfectly terminated, sapphire at one end and ruby at the other, opaque, to be sure, but yet beautiful and of very perfect formation, which weighed three hundred and twelve pounds. It is five times larger than any other corundum crystal, in either hemisphere, yet uncovered, and would be a center of attraction in any collection of minerals. It was purchased by Professor Shepard, and is in his collection at Amherst College.

A comparison of the associate minerals of the ruby of Pegu and the sapphire of Ceylon with those of the North Carolina locality gives the same companions, numbering more than a dozen varieties, many of them of great interest. A microscopical examination for structure and color matter made in my presence by Mr. H. C. Sorby, F.R.S., of Sheffield, England, and considered the best authority, showed an exact conformity to the gems of the Orient in all particulars, the color matter being due to the presence of chromium and uranium. These examinations go to prove the geological and mineralogical conditions of the corundum formations in both hemispheres are alike. While prospecting heavily in one part of the mountain, certain indications led me to reflect if it might not be possible to find geodes or nodules of chlorite carrying gems or crystals of corundum, similar in formation to the quartz geodes of Lake Superior, which in many cases are hollow, and lined internally with groups of beautiful amethysts. My thought was ultimately realized, with this difference: the nodules of chlorite were solid, yet some of them carrying crystals of brilliant color, though opaque like this specimen. I know of no reason why these geodes may not be found of the same character as those of quartz formation, and I will be greatly obligated to any scientific gentleman present if he will give us his views on this point.

You see upon the wall sectional drawings of the mine and its workings, with a general view of the locality.

The aspect of the ride is somewhat barren, like that of all the corundum and emery localities with which I am acquainted in any part of the world. The granitic rocks which make up the principal masses of the mountains in this locality have been fissured here with a large dyke of chrysolite and serpentine in which the corundum-carrying veins are found. These veins traverse the dyke, and are mainly composed of chlorite and chloritic minerals, carrying with them corundum in massive and crystal forms. The veins are five in number, dip to the north-west at an angle of forty-five degrees, and contain the mineral in size from microscopic crystals to lamellar crystalline masses of from one to five hundred pounds. The two varieties of chlorite known as ripidolite and jefferesite form the usual vein gangue or matrix of the mineral.

Among other interesting features of this locality, three seemed to me as of special interest to mineralogists. The finding of seemingly water-worn pebbles firmly bedded in the vein gangue some distance under ground.

The discovery of the finest gem in color at the bottom of the deepest shaft, its form a clearly defined crystal with perfect faces.

And the fact that crystals an inch in diameter from a depth of fifty feet could, when first brought to the surface, be broken like pipe-stems between the thumb and finger; but which, exposed to the sun and air for a few days, became firm and tough like those upon the surface.

One of the most striking features of this mine is, that I have never met any variety of corundum in granular or crystal form that I could not duplicate in all its peculiarities from the product of this locality.

COTTAGE BUILDING.

THAT is not true charity which takes cake and wine to fever cases in overcrowded dirty cottages, and leaves the overcrowding, dirt, and squalor unremedied. There are points of construction to be attended to which I will name, so as to put them on record for the remembrance of those who may, at some time or other, build cottages or small houses, or be in communication with those who do build, or are going to do so. Do not build on heaps of rubbish, fillings-in with cesspool refuse, chemical waste, or on swampy ground which cannot be drained. Thousands of houses have been so placed, and are now being so placed, in the suburbs of our towns. A bed of concrete over the site of cottages will vastly modify otherwise objectionable positions; but, indeed, a bed of concrete should be used in all cases.—*Rawlinson.*

THE DRAINAGE OF COUNTRY HOUSES.

By JAMES C. BAYLES.

THERE are situations and conditions which render practicable the system of house-drainage preferred by Col. Waring, which disposes of the iquid waste of the house by means of flush tanks, settling cisterns, and irrigation pipes. I have employed this system, somewhat modified, in draining my own country house, which stands on high country, and has a sloping lawn of more than a hundred feet width, in the best position for the accommodation of irrigated pipes. I do not believe, however, that the system is one which admits of general adoption, nor one which will meet the requirements of most householders living within the narrow limits of town or village lots. Even where practicable, it does not seem to me to possess the theoretical excellence which is claimed for it. In summer, when evaporation is rapid and vegetation active, it is possible that the organic matter in the waste of a house would be taken up and assimilated by plants as rapidly as it could decompose in the soil; but I am not quite sure that even this is true in all soils. I have watched very carefully the workings of the system in my own grounds; and while the lines of drain-pipe are laid within eighteen inches of the surface, which is quite even, I have failed to discover any indications of a more rapid or luxuriant growth of grass or weeds near the pipes than remote from them. If, however, it be conceded that the system works well in summer under average conditions, I fail to see that my buried pipes are much if any better than a leaching cesspool during the winter months, when the ground is frozen and vegetation dormant. During this time the ground surrounding, and particularly that underlying the pipes, becomes charged with impurities which it cannot dispose of in a legitimate way. Long before they can be appropriated by growing plants, thawing snows and heavy soaking rains carry these impurities deep into the soil where the plants cannot reach them. In a light porous soil, there is nothing to hinder these accumulations of six or seven months of each year from working down until the soil is saturated and our own or our neighbors' wells polluted. We have, in the Northern States, only about five months of warm "growing-weather;" and, in my judgment, draining into the soil during the other seven months means pollution of the soil.

From a careful study of the problem of house-drainage in unsewered neighborhoods, I am satisfied that the tight cesspool system is the only one which is practicable. I have many times during the past few years had occasion to recommend a plan of drainage which has the advantage of adaptation to all the conditions I have yet encountered in practice. It is neither an invention nor a discovery; but in these matters the attainment of good results is of much more consequence than novelty or ingenuity in the means employed. I contract with a responsible mason to build a cesspool as "tight as a bottle." The price depends somewhat upon circumstances; but as I select my mason, and give him to understand that he is to estimate honestly on the cost of first-class materials and workmanship, and not as a competitor for a contract to be given to the lowest bidder, the price is usually reasonable and the work always good. When there is plenty of room, I put the cesspool from fifty to sixty feet from the house; when the lot is small, I put it as far away as I can. In shape, the cesspool is much like an old-fashioned coffee cup; its size, taking an average, is five feet diameter at top, and six feet deep. I cover this with a stout platform, removable at will, from the middle of which rises a wooden chimney ten or twelve inches square in cross section, and three to five feet high, capped with one of Mr. Baldwin Latham's charcoal ventilators, or with a device embodying the same principle. At one side of the platform I set a pump—any one of several makes it adapted to the purpose—and run the suction pipe down to the bottom of the cesspool. This pump is a permanent fixture, and is always ready for use. The house connection is made in the usual way; but I have no traps at any point on the line of the main waste or soil pipe, or the house-drain proper. The soil-pipe is carried up of one size from the foundation wall to and through the roof. The branch waste-pipes are of course trapped; but I take the precaution to use traps which cannot lose their seals from any cause except evaporation. The danger to be apprehended from the absorption and transmission of cesspool gases by the water-seals of such traps is obviously very slight, at most. With the house-drainage system open at both ends, no accumulation of gases at any point where they can be held under pressure is possible.

When the cesspool is full, it can be emptied in any way most convenient. In a town or village where an odorless excavator can be ordered, it may be emptied by lifting out the ventilating chimney, and dropping the suction-pipe of the apparatus through the hole in the platform. If the householder must attend to the work himself, he can do it in one or two ways, according to circumstances. In summer, if he has a garden, he may employ it for surface irrigation. He can make a trough by nailing two boards together at right angles, and, putting one end of this under the spout of his pump, let the other end rest where the water will do most good. By providing two or three such troughs, made of long boards, he can irrigate a garden of considerable extent, and as frequently as may be needed. The organic matter, already partially decomposed, will be at once taken up by the plants; and the water is quickly absorbed by the dry surface soil, to be given off again in evaporation. In the winter, or in places where irrigation is not needed for the fertilization of a well-kept garden, the contents of the cesspool must be pumped into tight vessels of some sort, and carted away. A short piece of rubber tubing attached to the spout of the pumps, and half a dozen kerosene barrels with tight-fitting bungs, will give the householder an odorless excavator of his own.

Concerning the views expressed by my very intelligent friend, Mr. Towne, I can only say that, in my judgment, the leaching cesspool system is the worst which can be employed under any circumstances. I lately visited a town in which this system is carried out *par excellence*. The town is built upon a limestone formation, which is full of cracks and fissures; and to dispose of anything in the shape of waste, it is only necessary to dig down twenty or thirty feet, until the limestone is reached. Even privy vaults empty themselves. The town has a water-supply drawn from sources not reached by the pollution of the soil; but within three years it has had two epidemics of typhoid fever, and is never free from sickness of unmistakably zymotic origin. We must not forget that, in pouring sewage into the soil, we are poisoning it for the future, near and remote. Coming generations will suffer, even if we do not, the consequences of so reckless a disregard of the precautions which the experience of centuries has shown to be essential to the avoidance of conditions prejudicial to the public health.—*Amer. Arch. & Build. News.*

FIREPROOF CONSTRUCTION.

MR. GEORGE NORTHCROFT, a Liverpool architect, has introduced a system of fire-resisting compound-arches and roofs likely to promote its object in a marked degree. The patentee remarks that, in a country like England, where iron and fireclay abound, it is not necessary for the architect to have recourse to concrete in the construction of fireproof buildings. By the aid of machinery, clays can now be molded into any required form, and daily experience teaches, for strength and durability, in positions where the material is constantly exposed to the action of fire, none more reliable can be obtained than the fireclay goods made from the deposits of that material found in the mineral districts of this country. We recently pointed out that the nearest approach to an absolutely fireproof building would be one entirely constructed—if that were possible—of brick. Mr. Northcroft's patent system approaches this ideal as nearly as is practicable. By its adoption the floors and roofs can be constructed of brickwork, bonded together with iron, embedded in the work. The floors and roofs are simple in design, and intended to facilitate building operations by employing in their erection the bricklayers engaged carrying up the walls. No delay necessarily need occur. When the walls are brought up to the floor level, the flat centers are set, and the cast-iron wall-plates bedded on the walls, the rolled iron joists placed on their bearings, and the skew bricks bedded to them in a composite of asphalt, which renders expansion easy, and avoids disturbing the adjacent parts. The various arches are then filled in, and when the floor is completed the walls can be at once proceeded with up to the next floor level. The distance between the girders and their depth is determined by the load to carry and the width of the rooms.—*Building News.*

THE NATIONAL OPERA HOUSE, LONDON.

THE new Opera House now building on the Thames Embankment, of which we publish the exterior as designed, is a representative one of its class. The view from which our illustration is taken was one of the most striking drawings exhibited in this year's Royal Academy and, despite the adverse criticism which the design received at that time from one of our contemporaries, we must acknowledge that, with all its shortcomings, its front towards the river and the general grouping of its parts are characterized by a bold and expressive treatment. From the critic's opinion that the design was one of the ugliest in the Academy, and that its façade resembled piled up "tea chests," we must entirely dissent. There is a symmetry and balance of features; but the conical roof of the auditorium rising out of the rectangular masses of the grand foyer and flanking vestibules, the quadrant-shaped staircases which stop against the rising tower, like angles of the wings; the square mass behind the great cone emphasizing the stage, and the general lightness of the architectural detail combine to render the composition, as seen in our perspective, not wanting in antithesis and variety. As will be noticed, the treatment is thoroughly French, and the festive and operatic element is not lost sight of in the decorative adjuncts. The sportive and *allegresse* qualities are particularly marked in the transept-like arrangements of the corner towers, contrasting with the unbroken recessed attic above the grand foyer. The side facing south is certainly not so happy, and we come on a much more commonplace and hardly sympathetic treatment.

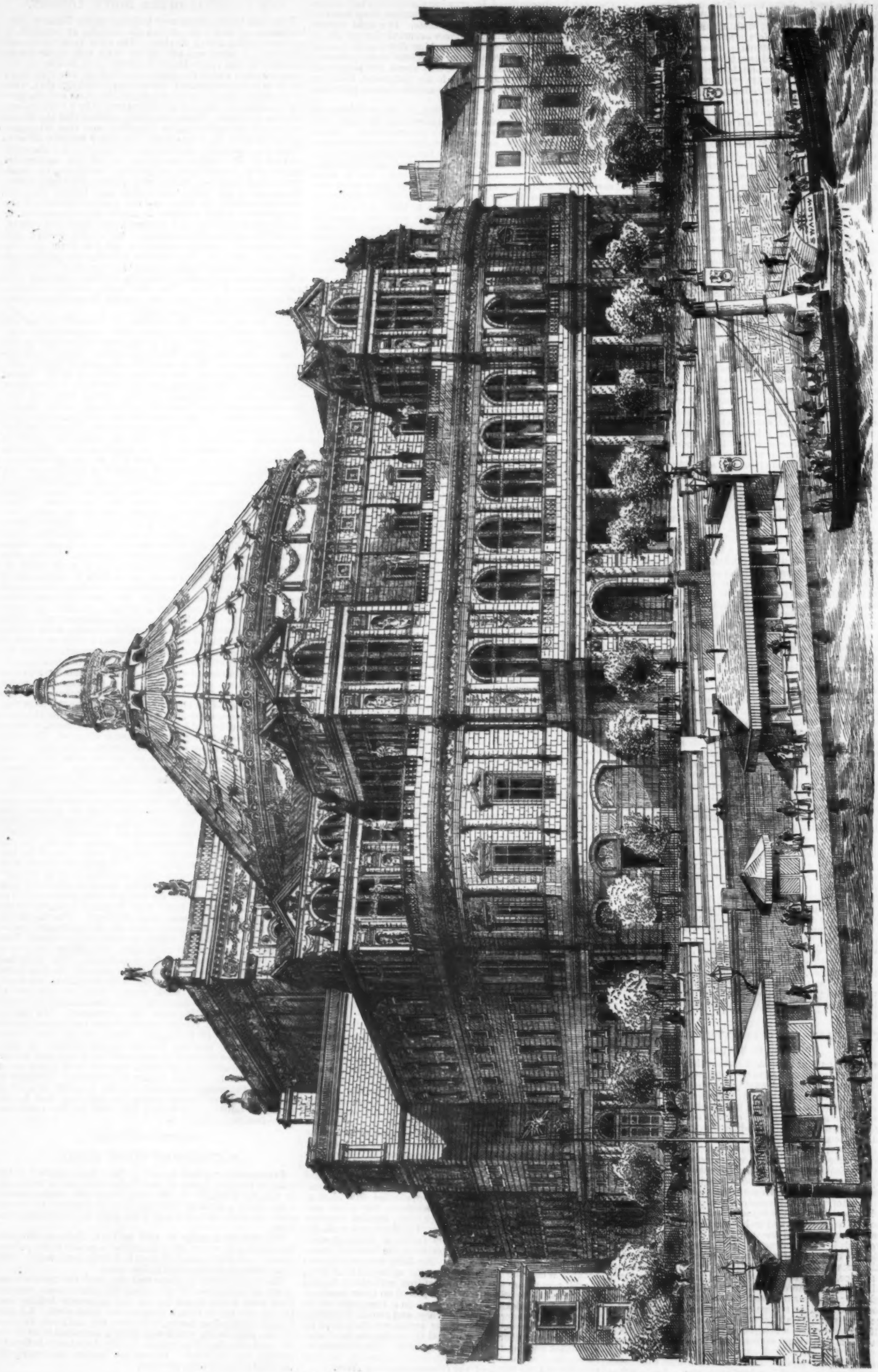
The general plan of the building is a parallelogram; and the inner shell or four bounding walls, comprising the auditorium and stage, which will be the most commodious in this country, measure about 200 ft. by 100 ft. About half this area, or a space of 102 ft. by 100 ft., is occupied by the auditorium, and the stage has a clear depth of 80 ft. Round three sides of this building, marked externally by the square attic-like mass of the stage and the conical dome, we have the entrances and vestibules in the front and returns, the private apartments for gentlemen and lady artists, and the royal vestibule, saloons, and official departments. Facing the Embankment, and shown in our view, the ground-floor level is entered by a vestibule of five archways, having in front an arcaded carriage way. Right and left of this vestibule, enriched by a detached range of columns of scagliola on each side, and extending the entire front of the façade 108 ft in length by 25 ft. in width, are the grand staircases of quadrant shape, leading to the "grand tier" and foyer. These are enclosed in the circular corners seen in the perspective. The stairs land on spacious and handsome lobbies leading into the grand tier. Passing through the ground-floor vestibules, the stall lounge below the pit tier is reached, while right and left are separate entrances and exits. No less than seven exits are provided. On the west side is the royal entrance, a circular-shaped angle porch with its own suite of rooms on the grand tier, comprising a smoking room, royal saloon, lavatories, etc. Between the grand entrance, vestibule, and the royal entrance, a separate entrance and staircase lead to the amphitheatre, stalls, and dress circle, while on the corresponding side a similar entrance leads to the amphitheatre. Besides these main stairs to different parts of the house, there are two staircases of intercommunication between the tiers of boxes, serving as general means of access. Thus, ample means of egress are provided, and several extra exits are shown on the plans. In a mezzanine below the stage a number of rooms are obtained as gentlemen's dressing rooms, etc. Reaching the "grand tier" by the front vestibule staircases, right and left, the boxes are double, each having an ante-box of 5 ft. leading to the box itself, which is 7 ft. deep, and a wide passage behind is obtained. The auditorium is planned, we understand, nearly on the lines of the Scala Theatre at Milan, and the curves seem to be well adapted to command easy view of the stage. We believe, also, the opinion of Sir Michael Costa, as to the internal shape, has been acted upon so as to insure acoustical conditions. The height of the stage has been arranged so that the scenery can be lifted either above the proscenium or go below the stage. The roof of the auditorium, externally conical, surmounted by a handsome lantern for ventilation, is entirely constructed of open iron ribs of a lattice pattern, the ribs gradually tapering from the springing to the curb of the lantern, which last is supported in a framework of iron resting on cross open girders. The covering is to be of zinc. Below this outer roof will be the internal decorative ceiling, the details of which are not yet fully perfected. The whole of the front is faced with Portland stone, the flanks with Burham bricks and stone dressings. The basement, from the great depth gone below the Embankment level—48 ft.—affords cellarage which, we hear, will be let off. This and the surplus land, it is thought, will almost bring in a sum sufficient to balance the ground rent. The work has now reached the level of the grand tier, and the iron cores of the vestibule and grand foyer, with the girders, are fixed, and the value of the work already done is estimated at £60,000. The works have, up to the present time, been well carried out by Mr. Webster, the contractor. We understand the contract for the ironwork has been taken by Mr. J. M. Stewart, of Darlington Works, at £14,000, while £90,000 is the contract for the superstructure. A large quantity of the material is prepared for fixing, and we understand that although the work has not been going on so fast as could be wished, owing to temporary difficulty in obtaining the amount necessary for the monthly advance to the builder, there is good reason for believing that by the spring the building will be in a fair state for the opera season.—*Building News.*

WATERPROOF STONE WALLS.

SYLVESTER'S method is said to have been applied to the walls of the gate house of the Eighty-sixth street reservoir, in Central Park, N. Y., the wall being still impervious to water under a head of thirty-six feet, as reported by the engineer in 1870, six and a half years after the application was made.

The Sylvester recipe is said to be as follows: Dissolve Castile soap in water, three fourths of a pound to the gallon; dissolve one half pound of alum in four gallons water, both to be completely dissolved before using.

The walls should be clean and dry, and the temperature of the air not below 50° (F.), when the solutions are applied. First with a flat brush lay on the soapwash boiling hot, taking care not to form a froth on the brickwork. Let this remain twenty-four hours, to become dry and hard; then apply the alum wash, which may be at a temperature of 60° or 70°, and allowing it to remain twenty-four hours before repeating the soapwash. Repeat the washes alternately till the wall is impervious to water.



NEW OPERA HOUSE, THAMES EMBANKMENT, LONDON.